CRUISE REPORT

R/V *Maurice Ewing* – Leg 96-08
St. John's Newfoundland to Bermuda
14 October 1996 – 21 November 1996

MID-ATLANTIC RIDGE BULLSEYE SEISMIC REFRACTION AND MULTICHANNEL REFLECTION EXPERIMENT

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Summary

Maurice Ewing leg EW96-08 carried out six major seismic refraction experiments and a 5-day pilot multichannel seismic reflection survey of a portion of the Mid-Atlantic Ridge lying between the Hayes and Oceanographer fracture zones in the central North Atlantic. This project, known as the Mid-Atlantic Ridge Bull's Eye Experiment, was designed to provide accurate measurements of variations in crustal thickness and velocity structure, and upper mantle anisotropy, along segments of a typical slow spreading ridge with contrasting morphologies and gravity signatures. High spatial resolution multichannel seismic reflection data were also obtained to image the velocity structure of the shallowmost crust and evaluate the effectiveness of new processing methods for suppressing scattered energy in seismic profiles collected in the rugged topography found at the Mid-Atlantic Ridge.

All of the major operational goals of leg EW96-08 were achieved. Ten WHOI OBH instruments were used in fifty-nine separate deployments during the leg (including one test deployment). All instruments were recovered and the data return rate was greater than 97%. In addition, 4 new ORB (Ocean Reftek in a Ball) seismic recording packages were tested for the first time at sea on this leg. Fifteen ORB deployments were made, including six test deployments. One instrument (ORB #4) was lost, and two other ORBs experienced some problems during their first two deployments. However, performance of the ORBs improved as the cruise progressed and by the final deployment the remaining 3 ORBs were fully operational and returning excellent data. The extensive testing of these new instruments on EW96-08 identified a number of ways to improve instrument robustness and performance. The total of 74 deployments and 73 recoveries on a single leg far exceeds the record of any previous WHOI seismology group program.

During EW96-08 seismic refraction lines were shot along the rift valleys of all three ridge segments lying between the Oceanographer and Hayes fracture zones and within the eastern and western rift mountains of segment OH-1. In addition, two major 3-D tomography experiments were carried out - one located near the mid-point of segment OH-1; the other located over the NTO separating segments OH-1 and OH-2. Record sections were plotted for all instruments at sea. Travel times were picked for the refraction line shot along the rift valley of segment OH-1 and a preliminary 2-D velocity model was obtained from a tomographic inversion of these data. This inversion shows major variations in crustal velocity structure along the OH-1 rift valley with anomalously low crustal velocities near both ends of the segment and higher crustal velocities near the center of the segment. Thin crust was found within the NTO between OH-1 and OH-2. A low velocity anomaly may be present at 3-4 km depth, just south of the bathymetric high near the midpoint of segment OH-1. Shot and CDP gathers from the multichannel work show a well-defined Layer 2A/2B event which can be mapped in the rift mountains and within the shallower parts of the rift valley. Weak, discontinuous Moho reflections are also seen in preliminary stacks of the multichannel reflection data produced at sea. Taken together, the seismic refraction, tomography, and multichannel seismic reflection data collected on EW96-08 will be well-suited to address a number of fundamental questions regarding the crustal structure and tectonics of the Mid-Atlantic Ridge.

1.0 Scientific Objectives

Crustal accretion at slow spreading ridges, like the Mid-Atlantic Ridge, is widely viewed as a three-dimensional, time-dependent process driven primarily by the nature of mantle flow beneath the ridge axis and the variable thermal and mechanical properties of the lithosphere forming along a segment. The discovery of gravity lows or "bulls-eyes" centered on spreading segments at the Mid-Atlantic Ridge, and the inference from these anomalies of large along-axis variations in crustal thickness, has led to the view that mantle flow beneath slow spreading ridges is highly focused and plume-like at the segment-scale. This focused upwelling model makes specific predictions about how crustal thickness should vary along-axis and between segments with different gravity signatures. At slow spreading ridges crustal extension and faulting may also significantly modify the structure of the crust after it is emplaced. In particular, it has been proposed that near segment offsets low-angle detachment faulting results in a major asymmetry in crustal structure and thickness between "inside" and "outside" corners.

The Mid-Atlantic Ridge Bull's Eye Experiment was designed to provide accurate measurements of variations in crustal thickness and velocity structure, and upper mantle anisotropy along three contrasting segments of the Mid-Atlantic Ridge lying between Hayes and Oceanographer transforms. Among the questions we hope to address with this experiment are:

- How are variations in crustal structure and thickness related to along-axis variations in mantle Bouguer anomaly and axial morphology? Specifically, is there a decrease in mean crustal thickness from segment OH-1 to OH-3 as predicted by gravity data?
- How is crust formed in the rift valley transformed by extension and faulting as it is uplifted into the rift mountains? Specifically, what is the difference in seismic crustal structure between "inside-corner" and "outside-corner" crust at segment OH-1?
- Can upper mantle anisotropy be measured beneath the Mid-Atlantic Ridge rift valley? Is the observed anisotropy pattern consistent with a segment-centered, diapiric mantle flow model?
- What is the thickness and velocity of seismic layer 2A in the Mid-Atlantic Ridge rift valley and how does it vary as crust is uplifted into the rift mountains? What are the seismic properties of Moho in crust created at a slow spreading ridge?
- What are the dimensions and properties of crustal low velocity zones or crustal magma bodies within the Mid-Atlantic Ridge rift valley? Specifically, what is the origin of the mid-crustal low velocity body inferred from previous seismic studies near the mid-point of segment OH-1?
- What is the seismic structure of a small, non-transform offset?

2.0 Operational Objectives

Six separate wide angle seismic refraction experiments were planned for EW96-08 including two deployments designed for 3-D tomographic imaging of ridge crest structure. In addition, five days of multichannel work were scheduled. The wide angle seismic refraction data were recorded by 10 Woods Hole Oceanographic Institution OBH, supplemented by 4 ORB (Ocean Reftek in a Ball) receivers. The ORBs are a new generation of sea floor seismic receiver under development at Woods Hole. This experiment represents the first deep water operational test of the ORBs. The wide angle data were shot using the *Ewing's* 130-liter (8495 cu. in.) airgun array fired at either a 90s or 120s shot interval. The vertical incidence reflection data were shot using a 10-gun, 3005 cu. in. airgun array fired every 16s and recorded on the *Ewing's* 160-channel, 4-km-long towed hydrophone streamer. The primary operational goals of this leg included:

- Six deployments of ten OBH instruments, including refraction lines on segments OH-1, OH-2 and OH-3, as well as two 3-D tomography experiments
- Collection of spatially dense (<30 m shot spacing) multichannel seismic reflection data to evaluate the feasibility of new processing methods for suppressing side-scattered energy in the rough topography of the Mid-Atlantic Ridge
- Operational test and evaluation of the new ORB instrument design
- Produce SEGY archive files of all OBH data; relocate all instruments, begin travel time picking and modeling of wide-angle refraction data
- Producing pseudo-real-time stacks of all MCS data and plots of shot gathers to monitor data quality and evaluate results (e.g. existence of layer 2A/2B arrivals)
- Complete post-acquisition editing of all Hydrosweep multibeam data

3.0 Cruise Narrative

Wednesday, Oct. 9th (JD283) - Detrick/Wooding arrive in St. Johns about 1600L. After we checked in at the Newfoundland Hotel, Steve Holbrook and Trine Dahl-Jensen briefed us on the results of the last leg, and the status of the various shipboard equipment (streamer, OBH etc.). Steve gave us a copy of the EW96-07 cruise report.

Thursday, Oct. 10th (JD284) - Detrick met with the Captain Ian Young, Chief Engineer Steve Pica, and Science Officer Joe Stennett. We confirmed plans to sail on Monday morning October 14th. Began organizing stuff shipped up in the small blue van. Picked up Hallinan and Bailey at the airport in the late afternoon. Windy, rainy day.

Friday, Oct. 11th (JD285) - Ewing moved to the fuel pier at about 1030L; by 1500L the ship was back at the main waterfront dock. Continued to set up lab.

Saturday, Oct. 12th (JD286) - Hallinan spent the morning checking out the four ORB instruments; three checked out fine, one had a loose Reftek board. Collins, Toomey, Barclay, Hooft, Hosford and Hussenoeder arrive in St. Johns.

Sunday, Oct. 13th (JD287) - Science party moved onto the ship. Skellig, Mazama, and Thielson set up in lab. Work-around to 10-base T connector on Mazama found. Many people enjoyed the fine weather today hiking around Signal Hill and blueberry picking. Kent and Lin arrive in the early evening completing the scientific party.

Monday, Oct. 14th (JD288) - The *Ewing* left the waterfront dock in St. Johns at about 0830L (1720Z) to begin EW96-08 under cloudy cool skies. As we sailed through the Narrows we had a nice view of the rocky headlands of the Newfoundland coast. The first Fire and Boat drill was held at 1020L and after lunch a general scientific meeting was held. Strong head winds (>20 kts) were encountered from a developing low pressure are over Newfoundland.

Tuesday, Oct. 15th (JD289) - Second day of transit south. Strong head winds encountered yesterday afternoon have died down to about 15 kts. At about 0230L we entered a fog bank along the southern edge of the Grand Banks. Around dawn we crossed the southern edge of the Grand Banks and moved into deeper water as the fog lifted. At ~0820L we started up the lab scientific watch. Later in the morning we held a science meeting to review plans for each deployment. OBH 22 was prepped and put in the steward's freezer for a cold test to see if the new Tattletale installed in this instrument by Jim Dolan at the end of the last leg solves the problems EW96-07 had with this instrument. Tuesday afternoon Collins and Hallinan worked through the check-out procedure for ORB 1. OBH 22 worked fine for the freezer test and both OBH 22 and ORB 1 were prepared for a test deployment the following morning.

Wednesday, Oct. 16th (JD290) - Third day of transit south. During the night a major front spinning off a major low pressure area centered over Newfoundland and Labrador swept across the ship. The front was accompanied by strong winds (gusts to 50 kts) and lightening. Seas quickly increased to sea state 7 resulting in a very uncomfortable day aboard ship. We canceled the planned ORB test deployment and hunkered down for the day. By mid-afternoon the barometer had begun to rise and the winds started to abate. During the evening ORB 1 was reprogrammed for a test deployment on Thursday.

Thursday, Oct. 17th (JD291) - Fourth day of transit south. At 0830L (1030Z) we stopped for a test of ORB 1. OBH 22 was deployed with ORB 1 tethered ~16 ft above it. This arrangement allowed us to both test OBH 22 (which had recording problems on the previous leg) and provide a back-up for the ORB 1 burn-wire release system. Both instruments were launched at 1135Z at 38°12.876'N, 39°56.010W. OBH 22 was on-bottom by 1255Z. Two airguns (#9 and #12) were fired for a short 1 hour test line from 1307Z (1st shot #167) to 1400Z (last shot#324). ORB 1 was released at 1440Z - it took about 15 minutes to burn through the release wire. After release, interrogation of the instrument was intermittent, presumably due to its upside-down configuration (with transducer pointing down and shielded by the glass ball). Nearer the surface we were able to range to it fine, and tracked it almost to the surface (slant range of less than 500m). The rise rate for ORB 1 was about 50 m/min; it was aboard at 1633Z. OBH 22 was released at 1641Z and aboard at 1819Z. After securing the OBH 22 frame we were underway again by 1841Z. Debriefing showed that both instruments recorded the test shots. ORB 1 still had ample battery voltage for a third 8 minute burn.

Friday, Oct. 18th (JD292) - Reached the Oceanographer-Hayes FZ area today. Began deployment 1 for OH-1 axial valley line at 1635Z. OBH were deployed at 10 sites (1.1 to 1.10) with ORBs tethered ~5 m above OBHs at site 1.1 (ORB 3) and site 1.4 (ORB 2). Site locations maps and a deployment summary table are included in Appendix 1. All instruments were programmed to begin recording at 0900Z on JD 292.

Saturday, Oct. 19th (JD293) - Final deployment at site 1.10 was completed at 0110Z. Since the instruments were not programmed to turn on for another 8 hours we steamed northeast along the edge of present multibeam coverage to the north end of the line before deploying the guns. This survey mapped two more small seamounts along the eastern extension of the 34°50'N seamount chain. We began airgun deployment at ~ 0745Z. We will fire a 20-gun, 8420 cu. in. airgun array with a 90 sec repetition rate at a nominal over-the-ground speed of 4.25 kts, for a shot spacing of ~200 m. Gun depth will be ~10-11 m. First shot was at 0902Z; we crossed over station 1.1 at the northern end of the line at 0959Z (shot #38) and reached station 1.10 at the southern end of the line at 2138Z (shot #505). We then reversed course and shot north along the line with a repetition rate of 120s. Final shot was at 23:00:19 (shot #547). Airguns were aboard by 2346Z, and we turned southeast to toward site 1.10 to begin recoveries.

Sunday, Oct. 20th (JD294) - Spent nearly all day recovering instruments from deployment 1 along the OH-1 rift valley. OBH 27, at site 1.10, was the first aboard at 0134Z. The final instrument, OBH 23 at Site 1.1, was aboard just after midnight. The recoveries went very smoothly under nearly ideal conditions as the recovery teams honed their skills. Debriefing showed that all of the OBH recorded good data. One ORB (ORB 3) failed to turn on. Bench testing reproduced this problem which may be in the RefTek electronics. ORB 2 recorded data but was contaminated with a one second noise spike.

Monday, Oct. 21th (JD295) - Steamed to site 2.1 for the beginning of the second deployment (see Appendix 2). This line will be shot along the rift axis of segments OH-2 and OH-3. In transiting to site 2.1 we diverted along a track to extend bathymetric coverage in the western rift mountains of segment OH-1. Rough seas and high winds made the going slow and rough. We finally reached station 2.1 at about 0730Z. OBH20 was launched at 0842Z. During the launch of OBH 17 at station 2.3 Emilie got her left hand caught between a tag line and the stern roller when the line snagged on the OBH frame. She had no broken bones (as far as we could determine) but she did have contusions, minor cuts and swelling especially around her knuckles. Instruments were deployed at 11 sites; site 2.1-2.5 along OH-2 and sites 2.8-2.13 along segment OH-3. We did not deploy any instruments at stations 2.6 and 2.7 in the NTO between segments OH-2 and OH-3 because of problems with ORBs 2 and 3 on the previous deployment. ORB# 1 was deployed at site 2.12; ORB 2 was deployed at site 2.13 tethered to OBH 24. All the deployments were completed by 0128Z on 22 Oct.

Tuesday, Oct. 22th (JD296) - The guns were streamed and the first shot on line 2 was at 0352Z on 22 Oct. (SP#1016). Shooting continued throughout the day. Because of a strong following current our speed through the water was quite low (~3 kts) resulting in relatively deep gun depths (~14-16 m). We had to increase our over-the-bottom speed to ~4.5-5 kts to keep the guns from towing too deeply. The last shot (SP#1808) was at 23:40:30.

Wednesday, Oct. 23th (JD297) - We immediately began recovering instruments, beginning at site 2.1. Debriefing of OBH 20, from site 2.1, revealed that it had turned off prior to the end of the line (~2130Z?) resulting in ~2 hr of data lost. After the recovery at site 2.4 about 30 minutes was spent recovering a US Navy drone found floating in the water making the *Ewing* the first missile-equipped UNOLS vessel! Recoveries continued throughout the day.

Thursday, Oct. 24th (JD298) - Continuing recoveries from deployment 2. OBH 24 at site 2.13 was aboard at 072Z. We then conducted an ~7 hr Hydrosweep survey to the beginning of deployment 3 filling in gaps in the existing French multibeam map. We arrived at site 3.1 at 1528Z and began deployments again (see Appendix 3 for site locations maps and a deployment summary table). We deployed 14 separate instruments on this line (10 OBH, 4 ORBs). ORBs 1 & 2 will be programmed in sleep/wakeup mode; ORBs 3 & 4 will be in continuous acquisition mode. Deployments continued through the rest of the day and into the next day.

Friday, Oct. 25th (JD299) - The final instrument (ORB 4) was launched at site 3.14 at 0653Z. We then steamed to a point ~6 mi north of site 3.14 to begin shooting. This airgun line will be shot with a 120 s shot interval. The first shot (#3003) was at 0932Z. Weather conditions are worsening with the approach of Hurricane Lili. Lili had sustained winds of 80 kts and gusts to 95 kts. By 1000L we were seeing force 8 conditions with sustained winds of over 30 kts, seas >12 ft, and a rapidly falling barometer. This made it difficult to keep the guns towing at depths of >8-10 m. A new weather report received in the early afternoon indicated the hurricane was strengthening (85 kts, gusts to 105 kts) and speeding up (~20 kts on course 070°). As we were only ~300 nm from Lili we decided to breakoff shooting line 3, recover the airguns, and run south. The last shot (#3197) was at 1600Z at location 35°02.27'N, 36°37.69'W. At 2200Z we shut down the lab watch.

Saturday, Oct. 26th (JD300) - As of 0600Z this morning Hurricane Lili was located at 39.1N, 38.8W about 350-400 nm to our north. Lili has weakened slightly now with winds of 65 kts and gusts to 80 kts. It is moving 060° at 20 kts. At breakfast time we were located about 15 nm west of the southern end of the deployment 3 shooting line, steaming at ~240° at 3-4 kts. The barometer is rising and winds have dropped to around 30 kts; seas are still >10-12 ft. At 1530Z we began deploying the airguns again to resume shooting line 3. First shot was (#3214) was at 1608Z; shot interval was 120 s. We turned onto the southern endpoint of line 3A at 1702Z and passed over site 3.1 at 1841Z. This course was in the trough (seas and wind out of the west) and both guns booms were dipping into the water on large rolls, in some cases up to the fifth gun winch.

Sunday, Oct. 27th (JD301) - During the night we continued to shoot line 3A and both wind and seas moderated. By morning, winds were less than 10 kts and seas had dropped to 3-5 ft. We passed over site 3.14 at 1236Z and completed this line at 1330Z. We then steamed southeast across the nodal basin to a point on the inside corner high at the northern end of segment OH-1. From there we shot line 3B down the eastern rift mts about 22 km from the ridge axis. First shot on line 3B was shot #4050 at ~2030Z.

Monday, Oct. 28th (JD302) - Last shot for line 3B was shot #4341 at 0542Z. Once the guns were aboard we steamed to site 3.1 to commence recoveries. OBH 22 was recovered at site 3.1 at 1121Z. Recoveries generally went smoothly with eight instruments aboard by the end of the day.

Tuesday, Oct. 29th (JD303) - Recoveries from deployment 3 continued. All went well until site 3.14 where ORB 4 had been deployed. ORB 4 was first interrogated at 0817Z but did not respond. Repeated attempts were made over the next several hours without success. Four separate burn (release) commands were sent and a surface visual survey was made but the instrument was not located. Finally, at 1300Z the search for ORB 4 was terminated. Later investigation suggested that ORB 4 may have flooded due to a bad replacement O-ring installed in the purge plug on this instrument. Because of rough sea conditions (25-30 kt winds; gusts to >40 kts) the planned MCS deployment was postponed. Instead we carried out a 9 hour multibeam survey of the western rift mountains of segment OH-1.

Wednesday, Oct. 30th (JD304) - Deployments began at 0130Z for line 4 in the eastern rift mts of segment OH-1; 8 OBH instruments were deployed from north to south (see Appendix 4 for site location maps and a summary deployment table). The final deployment was completed at 1048Z. Airguns were deployed and shooting commenced at 1211Z (shot #5000). We were on-line about 2 miles south of site 4.8 at 1245Z and passed over site 4.8 at 1313Z (shot #5031). Shot line 3A was run from south to north in eastern rift mts of segment OH-1; shot line 3B was run from north to south in the western rift mts.
Shooting line 4A was completed at 2130Z when we passed over site 4.1 (shot # 5279). After turning to the west the shot interval was increased to 240 s to see if this longer shot interval will improve S/N on these undershooting Pn arrivals.

Thursday, Oct. 31th (JD305) - Shooting line 4B began at site 3.13 at 0243Z (shot #5361). At about 0500Z a major front passed across the area bringing wind gusts up to 75 kts and sustained winds of over 40 kts. By breakfast time conditions had begun to moderate but remained back. Shooting line 3B was completed at 1139Z (shot #5495) and the airguns were retrieved. We then transited to site 4.8 to begin OBH recoveries for line 4 OBH 17 at site 4.8 was on-deck by 1705Z. By the end of the day four instruments had been recovered.

Friday, Nov. 1st (JD306) - Recoveries from deployment 4 were completed with the last instrument (OBH 24) on-deck at 0449Z. OBH 22 and OBH 24 were both found to have very noisy data. Because of bad weather during the undershoot line in the western rift mountains of OH-1 the data from that portion of this experiment is poor. After instrument recoveries were completed we transited to Site 3.14 and made another unsuccessful attempt to recover ORB 4. Following this we began the 5-day MCS part of the cruise. Weather conditions were ideal for this work. The tail buoy was launched at 0915Z; streamer deployment lasted until 0527Z on Nov. 2nd. The long deployment time was required because the streamer was so light from the prior leg on the East Greenland margin. We had to remove mucho gallons of oil, and used all available lead weights to get the streamer to tow at its proper depth.

Saturday, Nov. 2nd (JD307) Streamer deployment was completed at 0527Z; the guns were in the water by about 0700Z. We are using a 10-gun, 3005 cu. in. airgun array for the MCS operations. The guns were suspended by floats ~8 m below the sea surface. The shooting interval was 16 s; speed over the ground was ~3.5 kts giving a shot spacing of ~29 meters. We shot down the rift valleys of segments OH-2 and OH-3. We crossed site 2.1 at the northern end of segment OH-2 at 0745Z (SP#535). Appendix 15 for shotpoint maps and the MCS line log.

Sunday, Nov. 3rd (JD308) Continued with multichannel operations under ideal weather conditions. We reached the southern end of segment OH-3 at about 0630Z (SP#5653), then turned north along a line in the OH-3 rift valley about 1 km east of the previous line. At ~1730Z (SP#8019) we reached the northern end of OH-3 and turned east to run up the eastern rift mts of segment OH-2. Along this line we began to see layer 2B refractions in shot gathers; 2B velocities are 3.5-4.0 km/s. Today John Hallinan placed ORB 2 in a salt water bath on the fantail and was able to recreate the 1 sec noise spikes; however, the cause of these noise spikes remains unclear. Allegra Hosford suffered a fainting spell this evening.

Monday, Nov. 4th (JD309) Continued with multichannel operations; weather remains great. Spent the morning steaming up the rift valley of segment OH-1, then ran two N-S reflection profiles in the eastern rift mountains of OH-1. A data gap of 4 minutes occurred at 1415Z (SP#12779) when the gun shot monitor was closed by accident; a longer data gap occurred between 2046Z and 2111Z (SP#14247) when the CRU crashed. Otherwise operations went smoothly.

Tuesday, Nov. 5th (JD310) Continued with multichannel operations with 2 lines in the eastern rift mts of OH-1; one line across the rift valley, and a line in the western rift mts of OH-1. Weather conditions remain good and the data quality is high.

Wednesday, Nov. 6th (JD311) Last shot (#20372) was fired at 0000Z. All the guns were aboard by 0043Z; streamer recovery was completed by 0355Z. We then got underway to site 5.8 to commence OBH deployments for experiment 5. 13 instruments (10 OBH and 3 ORBs) were deployed at 11 sites (see Appendix 5 for site location maps and a summary deployment table); ORBs 2 and 3 were deployed tethered above OBH at sites 5.12 and 5.13. OBH 19 was launched at site 5.8 at 0555Z. Deployments were completed at 2302Z.

Thursday, Nov. 7th (JD312) We steamed to the northwest corner of the OH-1 tomography area to begin shooting. First shot (#6000) was fired at 0458Z. For this experiment the full 20-gun array will be used with a firing rate of 120 s and a ship speed of 4 kts. Planned shooting time is ~4 days. Weather conditions remain ideal.

Friday, Nov. 8th (JD313) Continued with 2nd day of shooting for OH-1 tomography experiment. Meanwhile plans were developed for the final deployment which will be a tomography experiment over the NTO separating OH-1 and OH-2

Saturday, Nov. 9th (JD314) Continued with 3rd day of shooting for OH-1 tomography experiment.

Sunday, Nov. 10th (JD315) Continued with 4th day of shooting for OH-1 tomography experiment. Last shot (#8706) was at 2214Z. At 2146Z we changed to a shot interval of 240 s for comparison with 120 s shots. The 240 s shots were numbers 8700-8706; the comparable 120 s shots were shots 8651-8669. After shooting was completed the guns were brought aboard and OBH recoveries began.

Monday, Nov. 11th (JD316) Recovering instruments from the OH-1 tomography experiment (deployment 5). OBH 22, at site 5.1, was brought aboard at 0017Z. ORBs 2 and 3, which had been tethered above OBH at sites 5.12 and 5.13 were successfully recovered and recorded good data (the 1 sec noise problem in the data has been fixed). OBH 27, located at site 5.9 in the eastern rift mountains of segment OH-1, had a red-colored, hydrothermal-like staining on the frame and glass ball hardhats. Recoveries continued throughout the day with the final instrument aboard at 1011L. ORB 1 and all of the OBHs recorded good data with the exception of OBH 23 which had very low amplitude signals traced to a faulty hydrophone and/or hydrophone cable. The hydrophone and cable were replaced for the next deployment.

Tuesday, Nov. 12th (JD317) After completing the recoveries for deployment 5 we immediately began deployments for the NTO tomography experiment (see Appendix 6 for site location maps and a summary deployment table). The first instrument was launched at 0130Z just 79 minutes after the last recovery from deployment 5. This was possible only because the instruments had been debriefed, backed up, rebatteried and programmed during the recoveries, and by having two teams for the recoveries and deployments that could work around the clock for two full days. Deployments continued throughout the day and were completed by 1736Z. Shooting for the NTO experiment began at 2000Z with shot #9042; rep rate was 120 s. Note: for this experiment the 540 cu. in. #9 gun was replaced with a 580 cu. in. chamber.

Wednesday, Nov. 13th (JD318) Shooting continued throughout the day. Average speed over the ground was 4 kts, but because of a strong westerly current we averaged only 3.4 kts over the ground shooting from east to west, but made ~4.6 kts over the ground when shooting from west to east.

Thursday, Nov. 14th (JD319) Continued with 2nd day of shooting for NTO tomography experiment.

Friday, Nov. 15th (JD320) Continued with 3rd day of shooting for NTO tomography experiment. Final shot (#11136) was at 1748Z. Instrument recovery began immediately and was completed in record time when the last (13th) instrument was pulled aboard at 1736Z. We then headed west for Bermuda at full speed.

Saturday, Nov. 15th (JD320) - Thursday, Nov. 21st (JD325) In transit to Bermuda. In order to effect necessary repairs on the LMF compressors, we were forced to run on three engines during most of the transit, allowing us to reach Bermuda on the afternoon of the 21st, at about 1500L, some 12 hours ahead of schedule.

4.0 Preliminary Cruise Assessment

OBH Operations and Data Quality

Six seismic refraction and tomography experiments were completed using between 8 and 13 instruments on each deployment (Figure 1). The first four experiments were conventional refraction lines (see Appendices 1-4). In the first experiment, a line was shot over 10 OBH deployed along the median valley of segment OH-1. In deployment 2 refraction lines were shot along the rift valleys of segments OH-2 and OH-3. Deployment 3 was an axis-parallel refraction line shot in the western rift mountains of segment OH-1, across the non-transform offset (NTO) separating segments OH-1 and OH-2, and in the eastern rift mountains of segment OH-2. Deployment 4 was a shorter refraction line shot in the eastern rift mountains of segment OH-1. For both deployments 3 and 4, shots were also fired along parallel lines in the opposing rift mountains of segment OH-1 in order to record Pn arrivals that undershoot the ridge axis. The final two deployments were designed specifically for 3-D tomographic imaging of axial structure - one experiment was located near the mid-point of segment OH-1; the other experiment was centered over the NTO separating segments OH-1 and OH-2 (see Appendices 5 and 6).

Instrument separation in these different experiments was typically 5-15 km. The source used was the Ewing's 8495 cu. in. 20-gun array (Appendix 7). Ship's speed was kept to a nominal value of 4-4.25 kts in order to maintain a gun depth of 12-14 m to improve the low frequency response of the array (Appendix 7). For the first and second deployments a shot interval of 90s was used giving a shot spacing of ~190 m. However, noise spectra showed a significant reduction in prior shot noise for a longer 120s s shot interval, especially in the 3-20 Hz band (Appendix 8), and the shot interval for the remaining four experiments was increased to 120s. Weather conditions during the first three experiments was less than ideal. Shooting for the fourth experiment had to be suspended for ~30 hrs due to the approach of Hurricane Lilly, and the western rift mountain line during the 4th deployment had to be reshot. However, weather conditions during the two tomography experiments was perfect.

Because of the need for rapid turnaround of the instruments, deployment and recovery operations were organized into two teams who worked 12 hours on and twelve hours off. This scheme worked well, although the nighttime "B" team suffered some culinary depravation as a result. Deployments of 11-13 instruments (10 OBH plus 1-3 ORBs) were typically accomplished in 12-14 hours; recoveries took 26-28 hours (except for the final recovery which took only 23 hrs!). In one instance, between deployments 5 and 6, the total time from the first recovery of instruments from deployment 5 to the last deployment for experiment 6 was only 44 hours. The first instrument for deployment 6 was launched just 79 minutes after the last recovery from deployment 5! This was possible only because the instruments had been debriefed, backed up, rebatteried and programmed during the recoveries using the two team approach.

The OBHs proved once again to be exceptionally rugged and dependable instruments with no losses in 59 deployments and over 97% data recovery. A summary of OBH configuration and performance is given in Appendices 10. Figures 2 and 3 show two representative OBH record sections. Crustal refracted arrivals are commonly observed out to 40-50 km range; Pn arrivals were seldom observed although a PmP phase was seen on some record sections (e.g. Fig. 2). Noise levels were generally higher than in previous experiments, e.g. the 1994 Hole 504B experiment. This may be attributable to several factors: (1) more scattering and reverberation of sound from prior shots due to the rugged, unsedimented basement at the Mid-Atlantic Ridge, (2) unusually shallow water depths in this area which resulted in some instruments being located in the SOFAR channel, (3) high levels of ship traffic in this area, and (4) high crustal attenuation in the axial region. Figure 3 shows an example of ship noise near 60 km range.

ORB Operations and Data Quality

EW96-08 saw the first deep-water deployments of the new WHOI seismic acquisition and recording system (see cover of Cruise Report). The acronym for this new instrument is ORB (Ocean Reftek in a Ball). ORB consists of a Reftek 72A-07 data logger placed in a 17" glass ball. For EW96-08, the ORB was deployed in OBH mode; a conventional hydrophone was rigidly attached to the hard-hat surrounding the glass ball. Four prototype ORBs were used during the cruise. Construction of these instruments was completed immediately prior to the cruise shipping date, resulting in only limited testing prior to the cruise.

Given the newness of these instruments and our lack of familiarity with their burn-wire releases, we decided that, at least for the first deployment of each ORB, the new instrument would be tethered above an OBH. Should the burn-wire release not work, recovery of the ORB would then be brought about by release of the OBH. A total of 15 ORB deployments were carried out during EW96-08, 6 of which were in tethered mode, and 9 in stand-alone mode. ORB configurations and a summary of release information are given in Appendix 11. Unfortunately, ORB 4 was lost during deployment 3 when we were unable to communicate with it to release it. Later investigation suggested that ORB 4 may have flooded due to a bad replacement O-ring installed in the purge plug on this instrument.

In general, the performance of the new instruments was encouraging. ORB 1 worked well on all deployments (see Figure 4 for an example record section). Initially, ORBs 2, 3, and 4 performed less satisfactorily. When programmed in "sleep mode", both ORBs 3 and 4 failed to awaken at the appointed time. This problem arose because the Reftek real-time clock was unable to retain date and time. This problem does not appear to be due to low voltages on the Reftek NiCd battery. We got around this problem by programming ORBs 3 and 4 in "continuous power mode". This work-around had the obvious drawbacks of (i) wasting power, and (ii) running the risk of a disk crash during deployment and recovery. ORBs 2 and 3 had an additional problem in that their data were severely corrupted by glitches with a 1 second periodicity. A detailed inspection of the data from ORB 1 also revealed these 1 second glitches but at a greatly diminished amplitude. Prior to the fifth deployment, we eliminated these glitches by adding an additional ground. The ORB data from the last two deployments appears to be of good quality.

The mixed performance of the ORBs is probably to be expected, given their newness. The improved performance of the ORBs as the cruise progressed is encouraging. The extensive testing of the new instruments on this cruise has identified a number of ways to improve instrument robustness and handling. These improvements are summarized in Appendix 13.

Preliminary Tomographic Image of OH-1 Rift Valley Line

A subset of data from the refraction profile shot along OH-1 were inverted at sea to obtain a preliminary image of the large scale seismic heterogeneity associated with this magmatically robust slow-spreading ridge segment. Instruments were deployed along a 90-km-long profile extending the length of the segment, from the Oceanographer transform southward to the non-transform offset near 34°35'N. Instrument spacing varied from 7 to 15 km and the shot spacing was approximately 190 m (90 s shooting interval). A total of 547 shots were recorded by 10 ocean bottom hydrophones. Because of variations in the signal-to-noise ratio, both with range and with variations in seafloor roughness, the number of identifiable first arrivals is approximately 3000 to 4000. PmP and Pn arrivals were also observed on several instruments, though these data are not included in the current analysis.

Onset times of 1,622 Pg arrivals (less than 50% of the data, not counting the PmP and Pn phases) were measured using an automated picking routine which uses an autoregressive method to identify an arrival from single trace data. This technique works best when the bandwidth of the data is broad with respect to the background noise. Data from the current experiment, in comparison with similar data collected from the less rugged East Pacific Rise, appear to be lacking in high frequency energy; this is presumably the result of scattering from rough topography and destructive interference at the high frequency end. In general, the variations in the signal-to-noise ratio and the decreased bandwidth of the present data limited the usefullness of the automatic picking routine. In the future, stacking of adjacent traces will improve the S/N ratio of the data and yield a larger and more accurate delay time data base. For the current travel time data, uncertainties vary from 10 to 80 msec (all picks were visually inspected to remove outliers).

For the ray tracing component of the tomographic analysis the inner floor seismic structure was parameterized by nodes spaced at intervals of 200 m in the along-axis and depth directions; perpendicular to the profile the nodal spacing was increased to 500 m in order to reduce the computational time. Seafloor topography, which varies by nearly 2 km along the length of the profile was explicitly included in the model parameterization. For the inverse problem, perturbational nodes were spaced at intervals of 2 km and 200 m in the along axis and depth directions, respectively.

Several inversions were conducted to obtain the final tomographic image shown in Figure 5. The starting model for the analysis was a one-dimensional velocity depth function taken from the work of Purdy and Detrick. This one-dimensional model was hung from the seafloor, producing a two-dimensional starting model with the isovelocity contours being conformable to the bathymetry. This assumption is what gives rise to the short wavelength variations in the velocity model (< 1 km) that undulate with the seafloor. Given the assumed Purdy and Detrick structure, an intermediate image was determined for a set of inversion parameters that yielded smooth, long wavelength (10 to 20 km) perturbations. This intermediate step was necessary to reduce non-linear ray tracing effects. The heavily smoothed image was then used as a starting model for the results shown in Figure 1. The rms travel time misfit relative to the Purdy and Detrick velocity model was approximately 400 msec. The rms misfit for the smoothed two-dimensional image and the final image was 0.124 and 0.098 s, respectively.

The results of tomographic imaging reveal several features that are presumably related to the segmentation of axial processes. First, P wave velocities show considerable lateral heterogeneity in the upper 3 km of the crust. Near the segment center velocities range from 6 to 6.75 km/s at depths of 2 to 3 km beneath the seafloor. By comparison, at similar depths beneath the distal ends of the segment the P wave velocity ranges from 4 to 5 km/s. The anomalously high velocities near the segment center are, on average, also greater than the results of Purdy and Detrick, which were obtained for a less magmatically robust segment of the ridge. A second noteworthy feature beneath the axial high is the detection of anomalously low velocities at depths of 3 to 4 km beneath the seafloor. Laterally, the low velocity anomaly, located just south of the bathymetric high, is approximately 0.5 km/s slower than velocities at similar depths to either the north or south. The anomalously high and low velocities near the segment center are attributed to enhanced magmatic activity in this area. At depths greater than 3 km beneath the seafloor the localized decrease in seismic velocity is likely due to elevated temperatures, for example, an increase in the average temperature of about 500°C could lower bulk velocities by 0.5 km/s. At depths less than 3 km, the anomalously high velocities may be associated with magmatic intrusions which have cooled and have not yet undergone tectonic fracturing or alteration by hydrothermal fluids, two phenomena which generally lower the velocities of mafic rocks. Near the distal ends of the ridge segment the low velocities at 2 to 3 km depth are presumably the result of extensive fracturing and alteration of mafic rocks. In this interpretation the segment-scale variation in seismic structure in the upper 3 km of the crust may be the result of enhanced intrusive activity near the segment center and the predominance of tectonic/alteration processes near the segment ends.

The limited Pg data used in this analysis does not sample the crust at depths greater than 5 to 6 km beneath the seafloor, thus crustal thickness variations throughout the segment are not well constrained. Upper mantle velocities, however, are observed as shallow as 5 to 6 km depth in the vicinity of the nodal deep, suggesting that the thickness of the crust north of +20 km is of this order. The record section shown in Figure 4 from within the NTO separating OH-1 and OH-2 indicates the presence of extremely thin crust (<2-3 km thick) with Pn arrivals at shot-receiver ranges of only 12 km. One final characteristic of the two-dimensional tomographic image is the undulations in isovelocity contours at depths of 2 to 3 km beneath the seafloor. Regions of anomalously high velocities at these depths show some correlation with seafloor volcanic edifices, suggesting that the anomalous structure may be related to the magmatic plumbing system beneath axial volcanoes.

Further analysis of these data will greatly improve the image quality and resolution. In particular, since the current image uses much less than 50% of the available Pg data, and none of the PmP and Pn data, we can expect that future results will achieve greater resolution and lower crustal depths and perhaps improved constraints on the variation in Moho depth throughout this segment of the Mid-Atlantic Ridge.

MCS Operations and Data Quality

Midway through the seismic refraction and tomography OBH deployments, a pilot multichannel seismic (MCS) reflection experiment (5 days) was undertaken to test the effectiveness of a DMO-based suppression scheme for removal of 3-D seafloor scattering which can render conventional 2-D seismic profiles useless, especially in regions where topography is acute (e.g. Mid-Atlantic Ridge). A second goal of this pilot experiment was to use the 4-km aperture (160 groups, 25-m spacing) of the MCS streamer to study the nature of the seismic layer 2A/2B boundary through modeling of individual common-mid-point (CMP) gathers using a Genetic Algorithm (GA)-based WKBJ waveform inversion scheme. The waveform modeling goal of this sub-experiment is aided by the atypical water depths found the Hayes-Oceanographer area which is, in part, related to the Azores hotspot which manifests itself as a northward, long-wavelength shoaling of the Mid-Atlantic Ridge. The anomalously shallow depths in this region ensure that refractions from the layer 2A/2B boundary can be observed within the 4-km aperture of the MCS streamer in many locales including the rift mountains lines, and near the center of segment OH-1.

Compared to previous MCS work near the Kane fracture zone, this pilot experiment is unique in several ways: (1) length of maximum offset is extended an additional ~1500 m (4100 m versus 2600 m) which is critical for imaging Moho events and layer 2A/2B refractions, and for DMO-based noise suppression, (2) dense shot spacing of approximately 25 m to minimize spatial aliasing which is a requirement for any DMO-based suppression scheme. To this end, a 10-gun array (Appendix 7) was floated to keep the guns at ~10 m depth for very slow tow-speeds of the MCS streamer (3.5-4.0 knots). Floating the guns has the added advantage of a very repeatible waveform from the source array, (3) compass-bird information was recorded to determine streamer feathering along the profile, which if not corrected for, can adversely affect moveout velocities of seafloor scattered energy, thereby nullifying any DMO-based suppression.

MCS shot records were acquired every 16 s with a 350 ms randomization which was induced to suppress previous shot noise. MCS data were recorded at a 2 ms sampling rate with a record length of 10 s. These data were recorded in SEGD format on 3480 tapes, then were decimated to 4 ms using SIOSEIS, and written in SEGY trace 0 format which is necessary to retain navigational and streamer depth information. These SEGY trace 0 records were temporarily archived on HP DAT DDS2 tapes, with a ratio of 35 3480 tapes per HP DDS2 tape (compressed mode), until they can be permanently archived on the mass-storage devices at SIO and WHOI. A tow-speed of 3.75 knots was attempted to achieve a nominal 33 m shot spacing. Due to a northerly current in this area, a 3.5 knot tow-speed was obtained for lines running N-S, and roughly 4.0 knots in reverse, which resulted in a shot spacing of nearly 25 m along S-N lines, and 35 m on the flip-side, give or take. The outer 3 km of the streamer rode well under these low two-speeds (10 m +/- 1m), while the inner kilometer seemed to sag at about 500 m (bad bird?) resulting in a few sections that were depressed by 10-15 m, although depth sensors along the streamer will allow this static shift to be measured, and if desired, removed (represents approximately 1-2 samples). Given the goals of this experiment, however, clearly the outer 3 km are of utmost importance, while the inner kilometer is likely to be tossed in our suppression scheme. The streamer seemed to stay behind the ship without any significant feathering which is critical for the success of our suppression technique; the ideal weather conditions during deployment and acquisition enabled a "nominal" MCS data set to be collected. In rougher seas, as experienced during the first portion of the OBH experiment, it is highly unlikely that: (1) the streamer would have been balanced correctly due to its initial "Greenland" configuration. (2) floating the guns would have been difficult to say the least. (3) streamer feathering might have been more. Any combination of the above factors would have significantly reduced the usefulness of any MCS data collected, in short, we LUCKED OUT! Lastly, the streamer was recovered in record 3 hours, amazing.

Quasi-real time processing of the MCS data was achieved using SIOSEIS, a seismic processing package developed by Paul Henkart at SIO, and a X-windows/PostScript seismic plotting package, pltsegy, developed by Dr. Alistair Harding at SIO. Both of these programs were run on a HP 9000 715/75 workstation which was configured with both a Fujitsu 3480 tape drive, and a HP DDS2 DAT tape drive. Seismic processing included: SEGD tape I/O, geometry, gather, NMO corrections w/ mute, stack, filtering, and SEGY disk I/O (Appendix XX). Subsequent to data acquisition, a separate tape copy process was run using SIOSEIS to copy SEGD 3480 tapes (35 per) onto SEGY trace 0 DAT DDS2 tapes (Appendix 16). This process could have been done during the realtime stack, but our line configuration was not laid out ahead of time which made the realtime copying mode during stack less flexible. NMO velocities were determined through interpolation of water depth/moveout velocity control points which enabled a 2-D stacking velocity field to be used based on water depth which is inserted into the SEGD header during acquisition. Velocities used during this experiment were closely tied to ESP velocities profiles along the East Pacific Rise, what else! A circular shot buffer was also part of our realtime scheme which allowed a timely inspection of raw shot gathers after each 3480 tape read. Updated stacked sections were typically plotted every new 1000 CMPs to inspect both data quality and variations in crustal structure /scattering. The HP workstation was easily able to keep up with the data flow, finishing each 3480 tape with 10 minutes to spare. The new generation of floating point workstations (e.g. HP C180/SGI IMPACT R10000) should allow FK filtering of shot gathers, if desired, into the realtime processing scheme, a real bonus for shallow water, multiple suppression types. The raw shot gathers seemed to be of good quality, with only a few traces (4 or less) being dropped out now and again; these traces were the locus of glitches which occasionally contaminated the shot gathers, which should ease the removal of these bad traces. There was only one "crash" of the DMS 2000 Digicon acquisition system which resulted in a loss of data, which was due, in part, to the sea-state, or "lake-state", encountered during acquisition. Our experience runs counter to the problems experienced by the previous leg off the coast of Greenland where the sea-state was typically unfavorable for acquisition, and a number of crashes occurred. The smoothness of our realtime processing was a function of Paul Henkart, author of SIOSEIS, making additional modifications on the previous leg, and our experience gained using SIOSEIS in this mode which I believe is at 4 or 5 cruises now. In fact no glitches were found in the realtime processing system, thankfully!

Preliminary MCS Results

Figure 6 shows the location of the MCS lines collected on EW96-08. Profiles were shot along the rift valleys of segments OH-1, OH-2 and OH-3, in the rift mountains of segments of OH-1 and OH-2, and a profile across the rift valley near the mid-point of segment OH-1. We imaged an ungodly number of scatterers in this rugged Mid-Atlantic Ridge topography, although some of the rift mountain lines seem to have very little *in situ* scattering. In fact, the easternmost rift mountain line along segment OH-1 is as scatter-free as any profile observed on the East Pacific Rise owing to its unique position above most of the potential scattering targets - go figure!. The most surprising aspect of the new reflection data set is the lack of continuous Moho, although some Moho was definitely imaged (Figure 7). On the rift mountain lines where topography and scattering is minimal, even in comparison to profiles along the East Pacific Rise, Moho is not a continuous feature, but appears to be patchy, although it is not packet like observed near the Blake Spur Fracture Zone. When Moho was observed in the realtime stacks, it typically lies at 2.1 +/- 0.1 s (moveout velocity ~3250 m/s), which is very similar to that seen within the Blake Spur Fracture Zone MCS data set. To date, no apparent thinning of "reflection" Moho has been seen away from segment centers. The Moho events we imaged had surprisingly constant travel time thickness, although our post cruise processing including DMO suppression should help clarify the along-strike continuity and nature of Moho beneath these three segments. Nonetheless, it is clear that Moho can be imaged, but it is not a continuous feature in this locale.

There were three potential "magma-chamber-like" reflections imaged in these data, two along segment OH-2, and one in the central rift valley high of OH-1 (Figure 8). Moveout velocities of the targets along the axial OH-2 profile are greater than expected if the event originated at seafloor, with the caveat that streamer feathering was not significant which we can verify ashore. Moveout of this "AMC-like" event was ~2350 m/s which is only slightly less (~100 m/s) than expected in comparison to a rise-axis East Pacific Rise ESP velocity model. The frequency content of these events along OH-2 are different than observed from seafloor scattering which gives us additional hope. In contrast to the East Pacific Rise, these targets if generated from melt sills, are only a few kilometers in along-strike length, in comparison to many 10s of kilometers along faster spreading ridges. Many fault-like dipping reflectors were also imaged along the axial profiles; forward modeling and suppression techniques will likely show these features are related to seafloor scattering, and not images of any low-angle detachment faulting. In any case, these new data should help clarify this issue.

Refractions from the layer 2A/2B boundary were observed along all of the rift mountain profiles, and at the center of segment OH-1 where the seafloor shoals to nearly 2200 m. After sorting raw shot gathers into common midpoint (CMP) gathers and stacking to increase signal to noise, we were stunned by the beauty of some of these gathers, which show clear layer 2A/2B refractions extending in some cases upwards of a kilometer behind the water-wave. Figure 9 shows one such stacked CMP gather for the saddle point center of segment OH-1. A supergather from the easternmost rift mountain profile of OH-1, where the shallow water has thrown more of the 2A/2B refraction within the aperture of the streamer, is shown in Figure 10. Unlike the East Pacific Rise, where layer 2A refractions exhibit a "reflection-like" character, the layer 2A refraction here can be seen both behind, and in front of the water-wave. Preliminary travel time analysis suggests that this may be the result, in part, of a step-like isovelocity layer (~100 m) at the surface, followed by two pronounced step-like velocity gradients beneath (Figure 11). This structure is in contrast to the East Pacific Rise where a single gradient layer, to first order, is overlain by a scuz layer which is not isovelocity in character. Our cursory analysis also suggests that the extrusive section is slightly thinner than at the East Pacific Rise, on the order of several hundred meters. This is not in agreement with results from the last such survey at the Mid-Atlantic Ridge over a decade ago, which may be a result of localized variability of the extrusive pile. or changes that exist segment to segment. These data should provide some new constraints on the nature of the shallowmost crust along slow spreading ridges.

Figure Captions

Figure 1 - Bull's Eye Experiment study area on the Mid-Atlantic Ridge between the Oceanographer transform at 35°15'N and the Hayes transform at 33°30'N. The three ridge segments between these two fracture zones are designated from north to south OH-1, OH-2 and OH-3. Shown are the instrument locations and shooting lines for the six seismic refraction and tomography experiments carried out on EW96-08.

Figure 2 - Record section from OBH 25 at site 1.8 for shots along the rift valley of segment OH-1. Site 1.8 is located about 10 km south of the midpoint of segment OH-1. Negative ranges are for shots north of the receiver. Note the clear crustal refracted arrivals out to ~50 km range. Pn arrivals may be present near the south end of the profile; a clear PmP phase is observed between 20 and 45 km range north of the instrument.

Figure 3 - Record section from OBH 27 at site 1.10 for shots along the rift valley of segment OH-1. Site 1.8 is located at the southern end of segment OH-1. Note the ship noise for shots about 60 km northof the receiver.

Figure 4 - Record section for ORB 1, the marine RefTek seismic recording package tested for the first time on EW96-08. The data quality is comparable or superior to that recorded by our older OBH instruments. This record section is from the non-transform offset separating segments OH-1 and OH-2 and demonstrates the presence of anomalously thin crust in the area (Pn observed at ~12 km range).

Figure 5 - Preliminary tomographic image of axis-parallel seismic structure along segment OH-1. P wave velocity is contoured at 0.25 km/s interval. Position of 10 ocean-bottom hydrophones are shown by asterisks. The approximate location of the Oceanographer fracture zone and the non-transform offset are indicated. Resolution varies throughout the image; see text for discussion of resolvable features and details of analysis.

Figure 6 - Bull's Eye Experiment study area on the Mid-Atlantic Ridge showing the location of the MCS reflection profiles acquired on EW96-08.

Figure 7 - Real-time shipboard stack of rift valley line OH-2A showing (on the left) a weak Moho reflection at ~6 sec TWTT, and (on the right) a very strong event at ~5.4 sec TWTT that could be a reflection from a crustal magma body.

Figure 8 - A portion of line OH-1A along the rift valley of segment OH-1 showing an event at about 4.5 sec TWTT that could either be a diffraction from a small crustal magma body or a scattering artifact from seafloor topography.

Figure 9 - Supergather from the rift valley near the mid-point of segment OH-1. Note the layer 2B refraction just emerging from the seafloor reflection at ~3.5 km offset.

Figure 10 - Supergather from the eastern rift mountains of segment OH-1. With the shallower water depths in this area the layer 2B refraction emerges from the seafloor reflection at offsets of about 2.9 km. The layer 2A refraction can be seen both behind and in front of the seafloor reflection.

Figure 11 - Preliminary upper crustal velocity model for OH-1 rift mountains from forward modeling the supergather shown in Fig. 10. The Purdy (1986) model for the MARK area is shown for comparison.

BULLSEYE Cruise Study Area, Deployment Overview

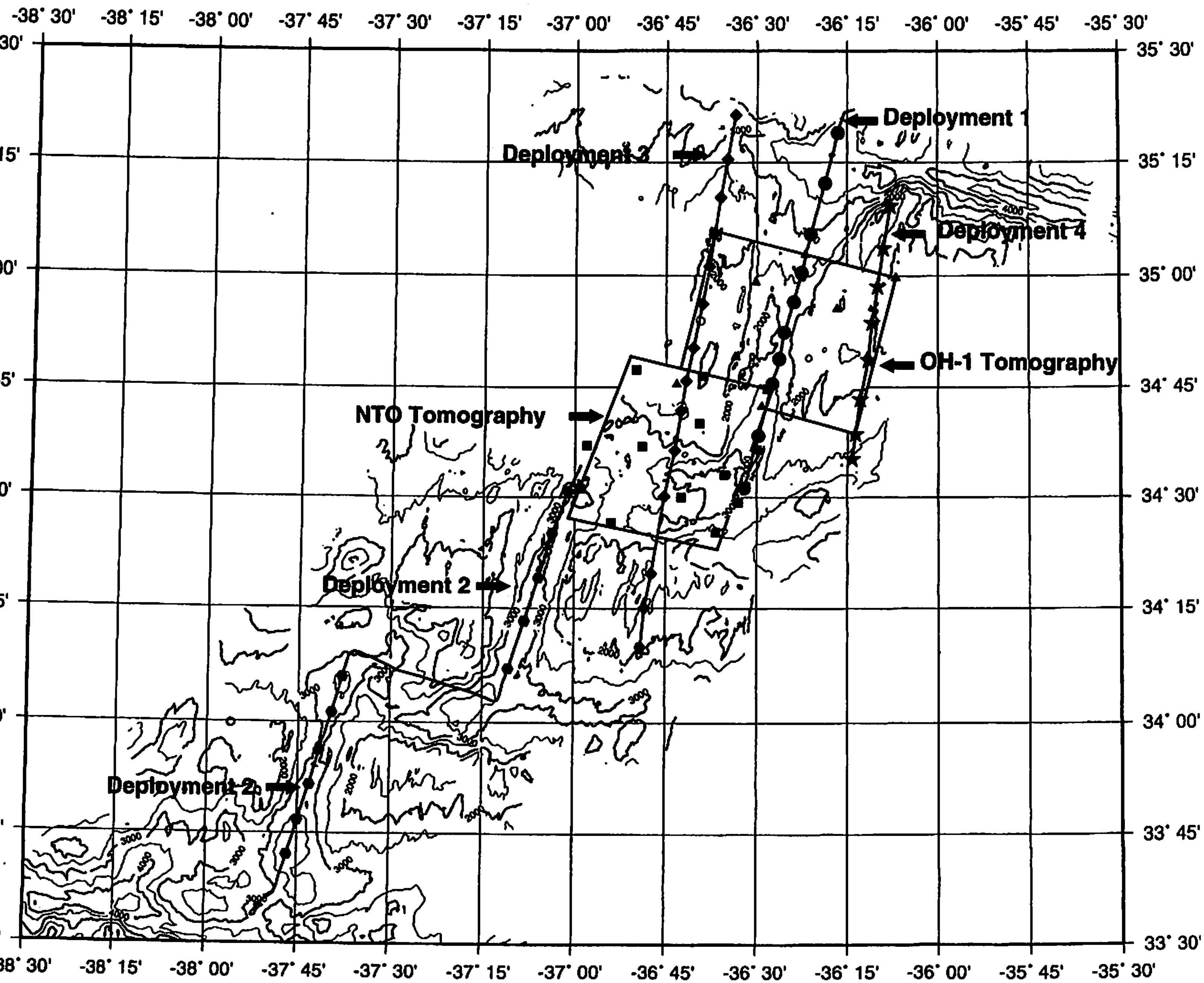


Figure 1

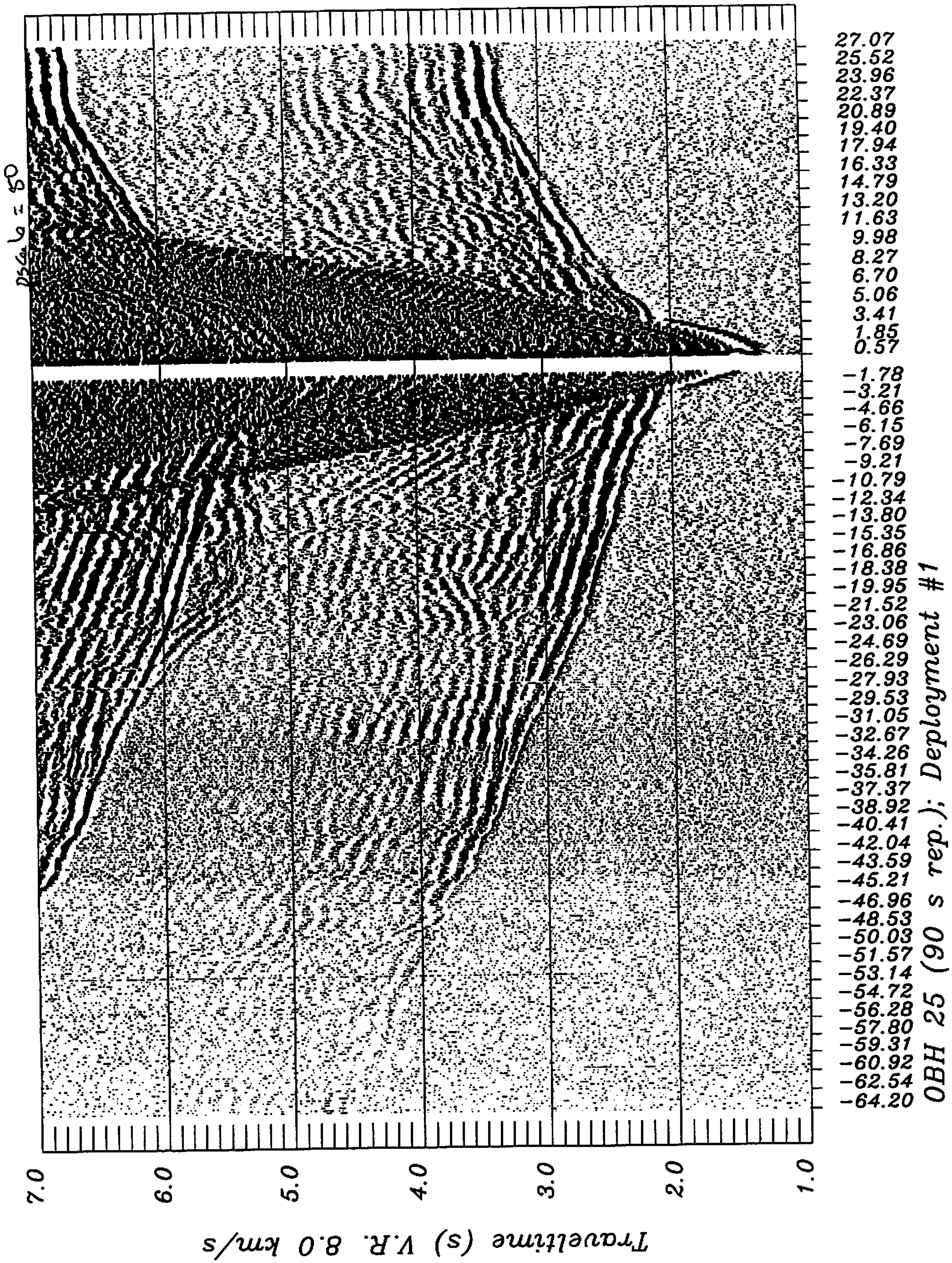
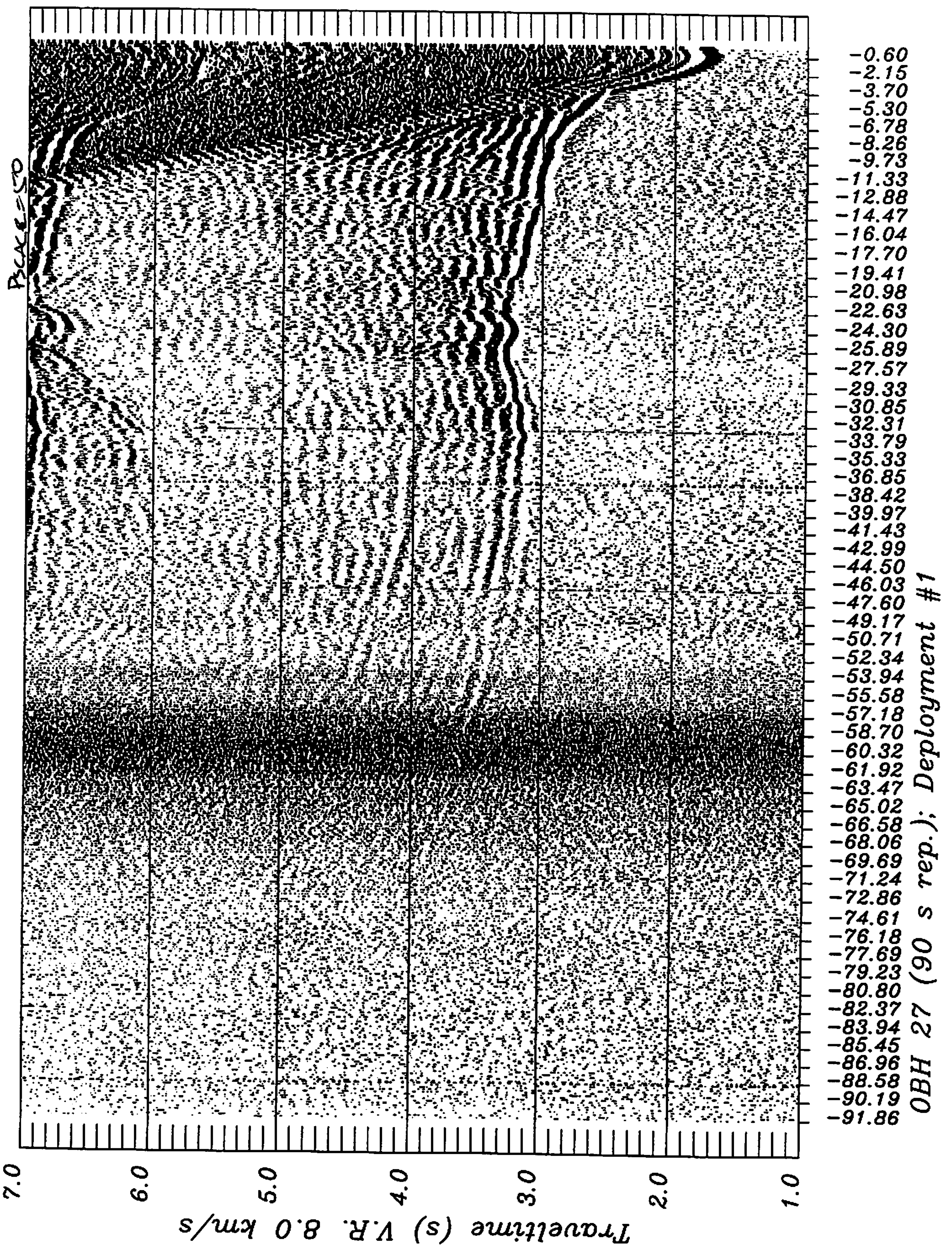

OBH 25 (90 s rep.); Deployment #1
Traveltime (s) V.R. 8.0 km/s
1.0
2.0
3.0
4.0
5.0
6.0
7.0
27.07
25.52
23.96
22.37
20.89
19.40
17.94
16.33
14.79
13.20
11.63
9.98
8.27
6.70
5.06
3.41
1.85
0.57
-1.78
-3.21
-4.66
-6.15
-7.69
-9.21
-10.79
-12.34
-13.80
-15.35
-16.86
-18.38
-19.95
-21.52
-23.06
-24.69
-26.29
-27.93
-29.53
-31.05
-32.67
-34.26
-35.81
-37.37
-38.92
-40.41
-42.04
-43.59
-45.21
-46.96
-48.53
-50.03
-51.57
-53.14
-54.72
-56.28
-57.80
-59.31
-60.92
-62.54
-64.20

Figure 2


OBH 27 (90 s rep.); Deployment #1
Traveltime (s) V.R. 8.0 km/s
7.0
6.0
5.0
4.0
3.0
2.0
1.0
-0.60
-2.15
-3.70
-5.30
-6.78
-8.26
-9.73
-11.33
-12.88
-14.47
-16.04
-17.70
-19.41
-20.98
-22.63
-24.30
-25.89
-27.57
-29.33
-30.85
-32.31
-33.79
-35.33
-36.85
-38.42
-39.97
-41.43
-42.99
-44.50
-46.03
-47.60
-49.17
-50.71
-52.34
-53.94
-55.58
-57.18
-58.70
-60.32
-61.92
-63.47
-65.02
-66.58
-68.06
-69.69
-71.24
-72.86
-74.61
-76.18
-77.69
-79.23
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-83.94
-85.45
-86.96
-88.58
-90.19
-91.86

Figure 3

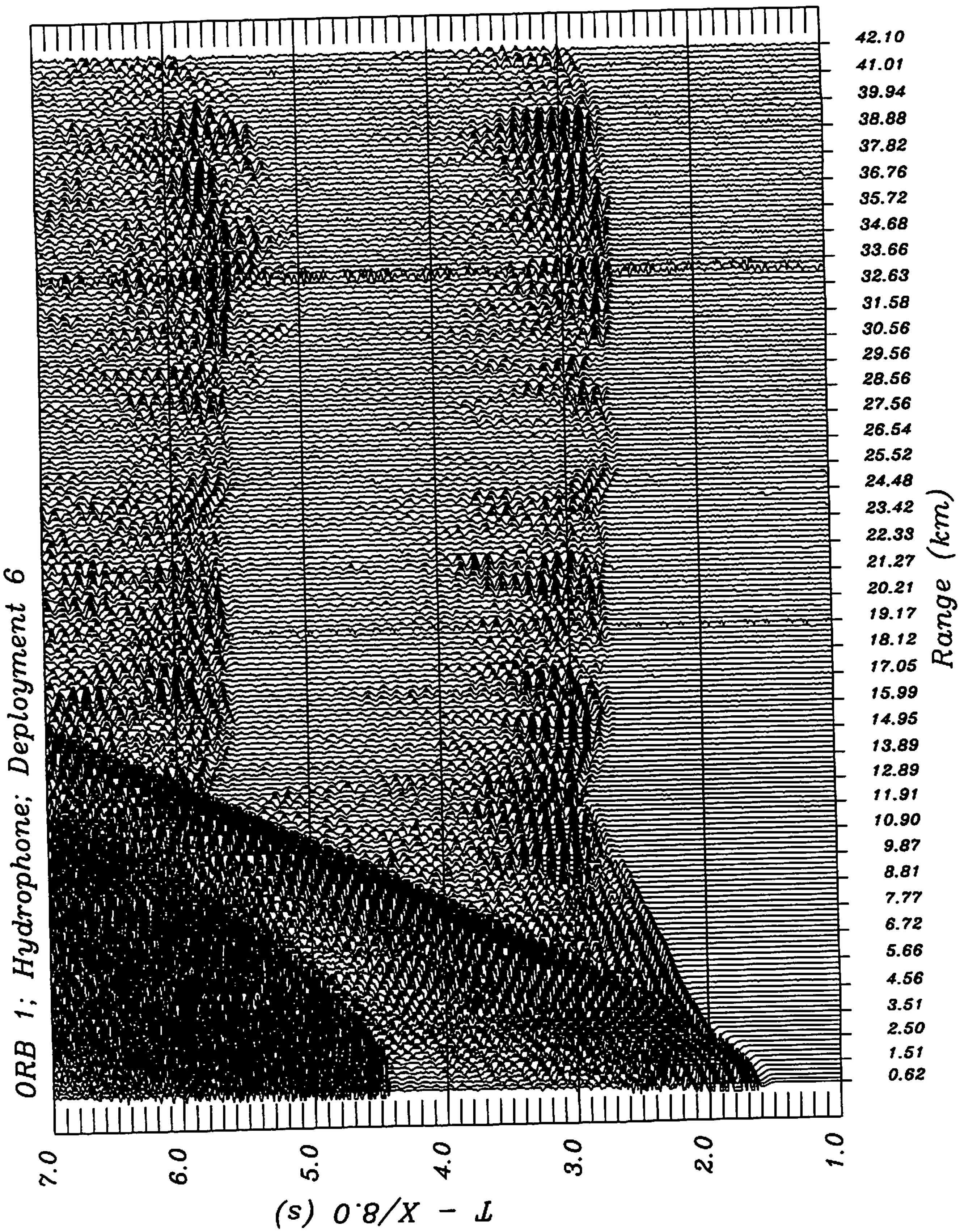

ORB 1; Hydrophone; Deployment 6
Range (km)
42.10
41.01
39.94
38.88
37.82
36.76
35.72
34.68
33.66
32.63
31.58
30.56
29.56
28.56
27.56
26.54
25.52
24.48
23.42
22.33
21.27
20.21
19.17
18.12
17.05
15.99
14.95
13.89
12.89
11.91
10.90
9.87
8.81
7.77
6.72
5.66
4.56
3.51
2.50
1.51
0.62
7.0
6.0
5.0
4.0
3.0
2.0
1.0
T - X/8.0 (s)

Figure 4

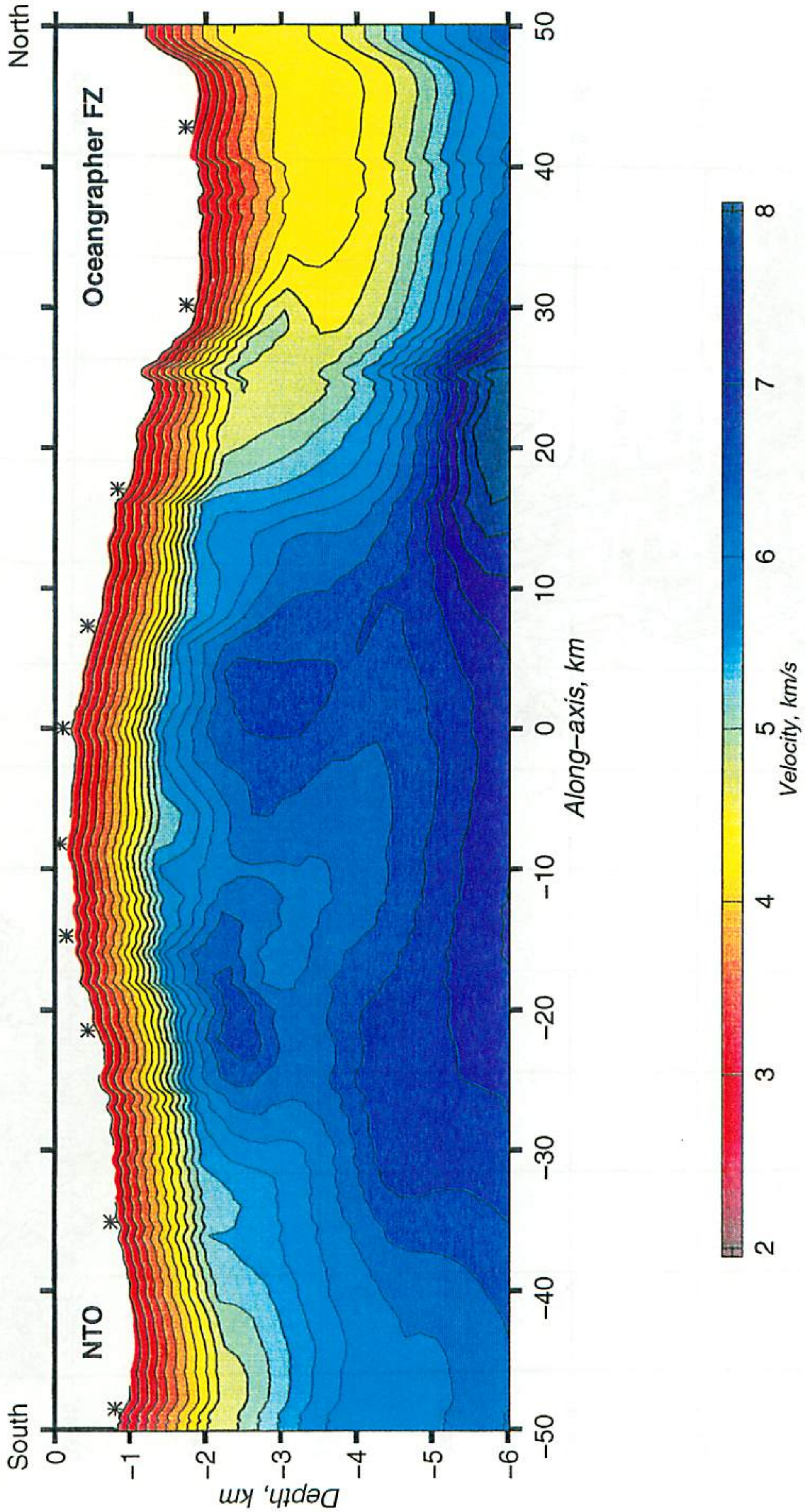

North
South
Oceangrapher FZ
NTO
Depth, km
Along–axis, km
Velocity, km/s

Figure 5

BULLSEYE Cruise, Shot Points During MCS

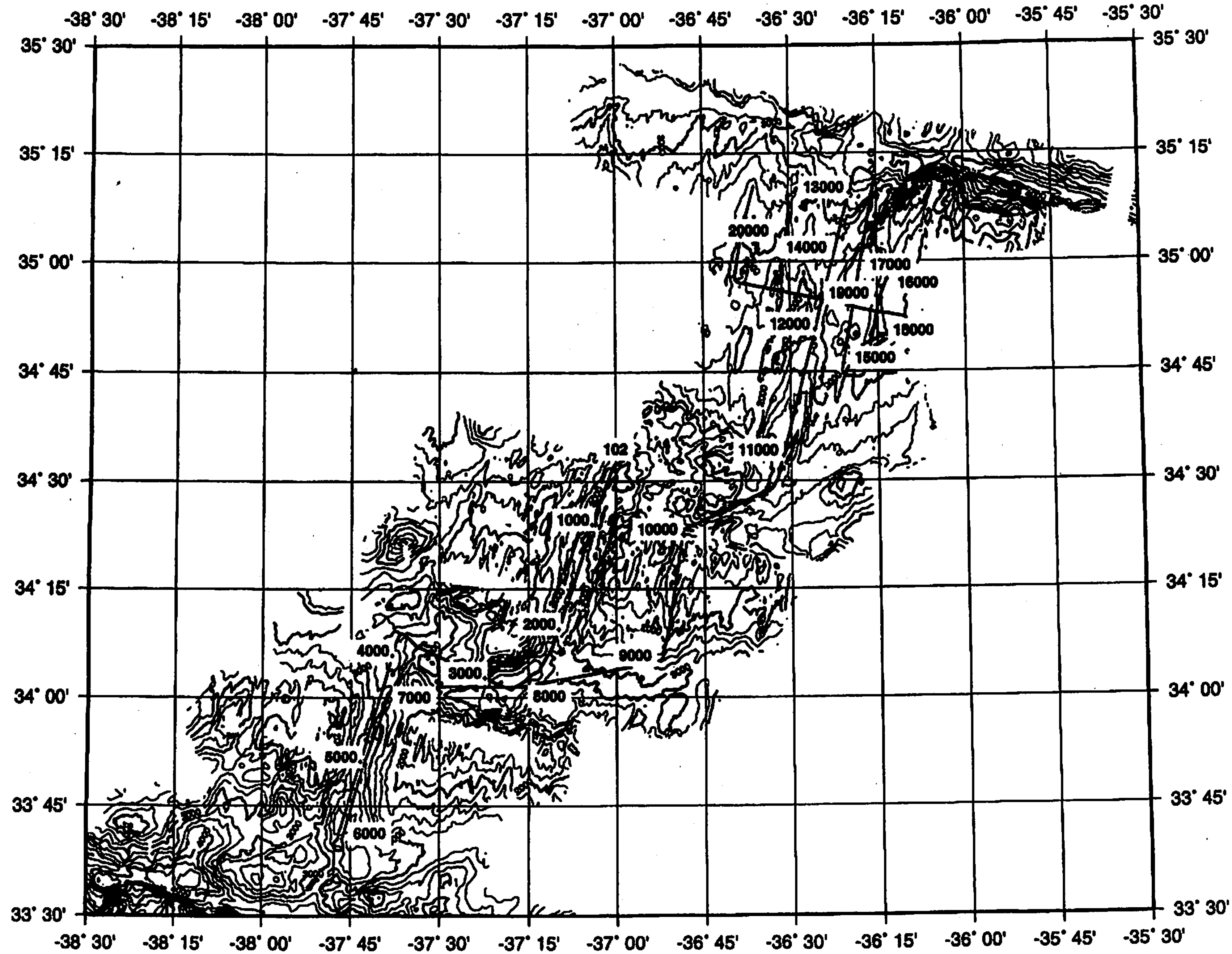


Figure 6

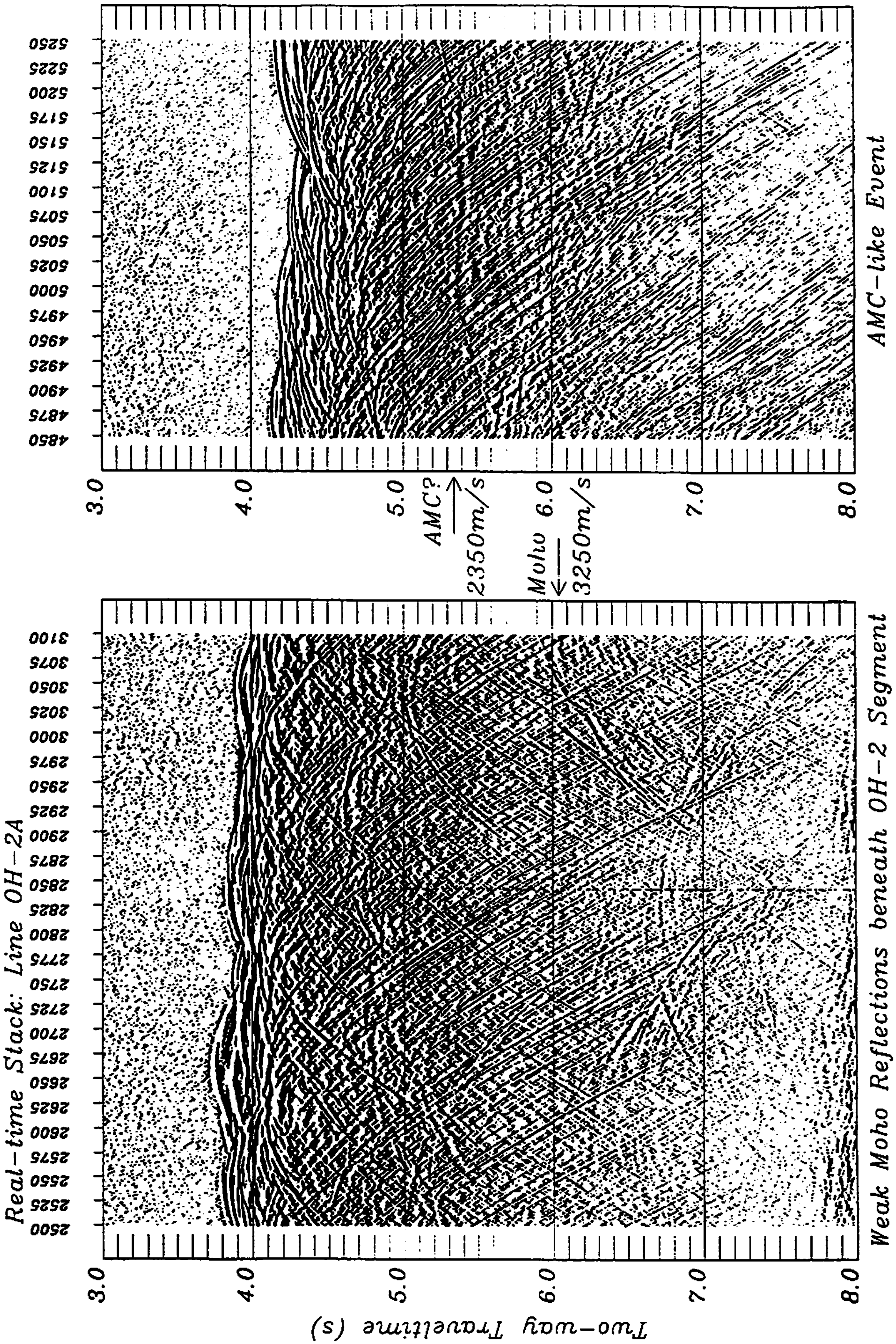

Real-time Stack: Line OH-2A
Weak Moho Reflections beneath OH-2 Segment
AMC-like Event
AMC?
2350m/s
Moho
3250m/s
Two-way Traveltime (s)
3.0
4.0
5.0
6.0
7.0
8.0
2500 2525 2550 2575 2600 2625 2650 2675 2700 2725 2750 2775 2800 2825 2850 2875 2900 2925 2950 2975 3000 3025 3050 3075 3100
4850 4875 4900 4925 4950 4975 5000 5025 5050 5075 5100 5125 5150 5175 5200 5225 5250

Figure 7

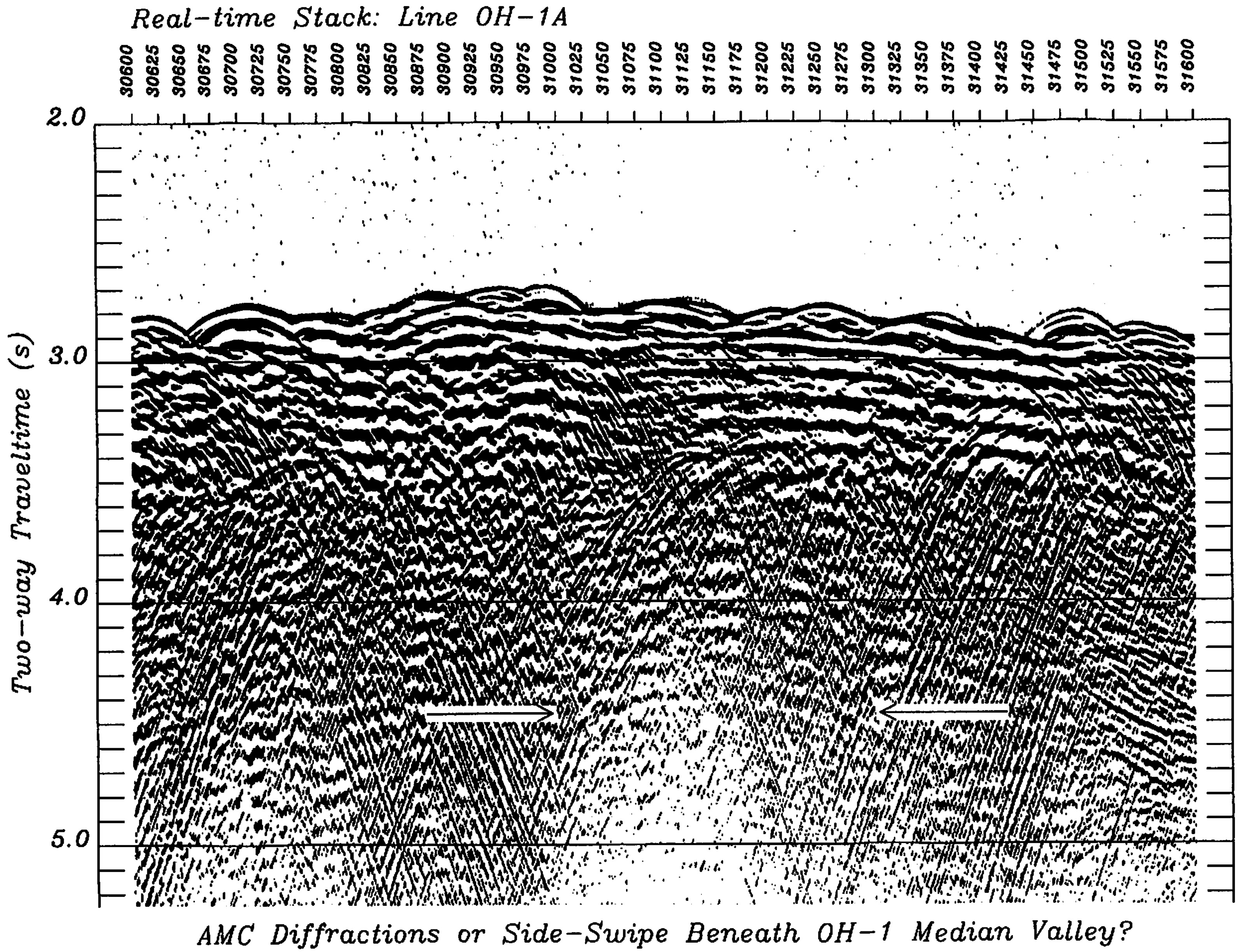

Real-time Stack: Line OH-1A
30600 30625 30650 30675 30700 30725 30750 30775 30800 30825 30850 30875 30900 30925 30950 30975 31000 31025 31050 31075 31100 31125 31150 31175 31200 31225 31250 31275 31300 31325 31350 31375 31400 31425 31450 31475 31500 31525 31550 31575 31600
2.0
3.0
4.0
5.0
Two-way Traveltime (s)
AMC Diffractions or Side-Swipe Beneath OH-1 Median Valley?

Figure 8

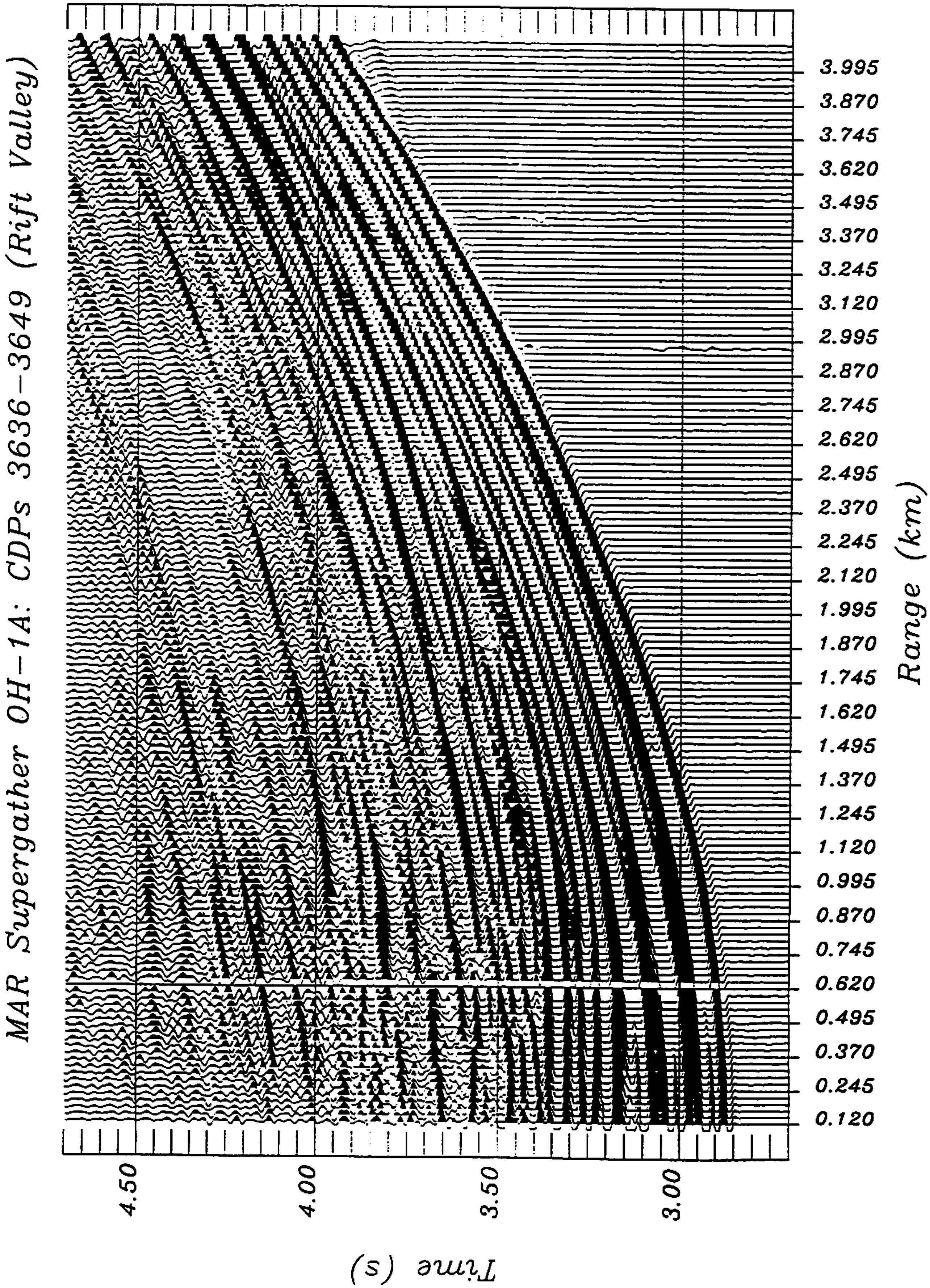

MAR Supergather OH-1A: CDPs 3636-3649 (Rift Valley)
Range (km)
3.995
3.870
3.745
3.620
3.495
3.370
3.245
3.120
2.995
2.870
2.745
2.620
2.495
2.370
2.245
2.120
1.995
1.870
1.745
1.620
1.495
1.370
1.245
1.120
0.995
0.870
0.745
0.620
0.495
0.370
0.245
0.120
Time (s)
4.50
4.00
3.50
3.00

Figure 9

MAR Supergather OH-1F: CDPs 959-973 (Rift Mountains East)

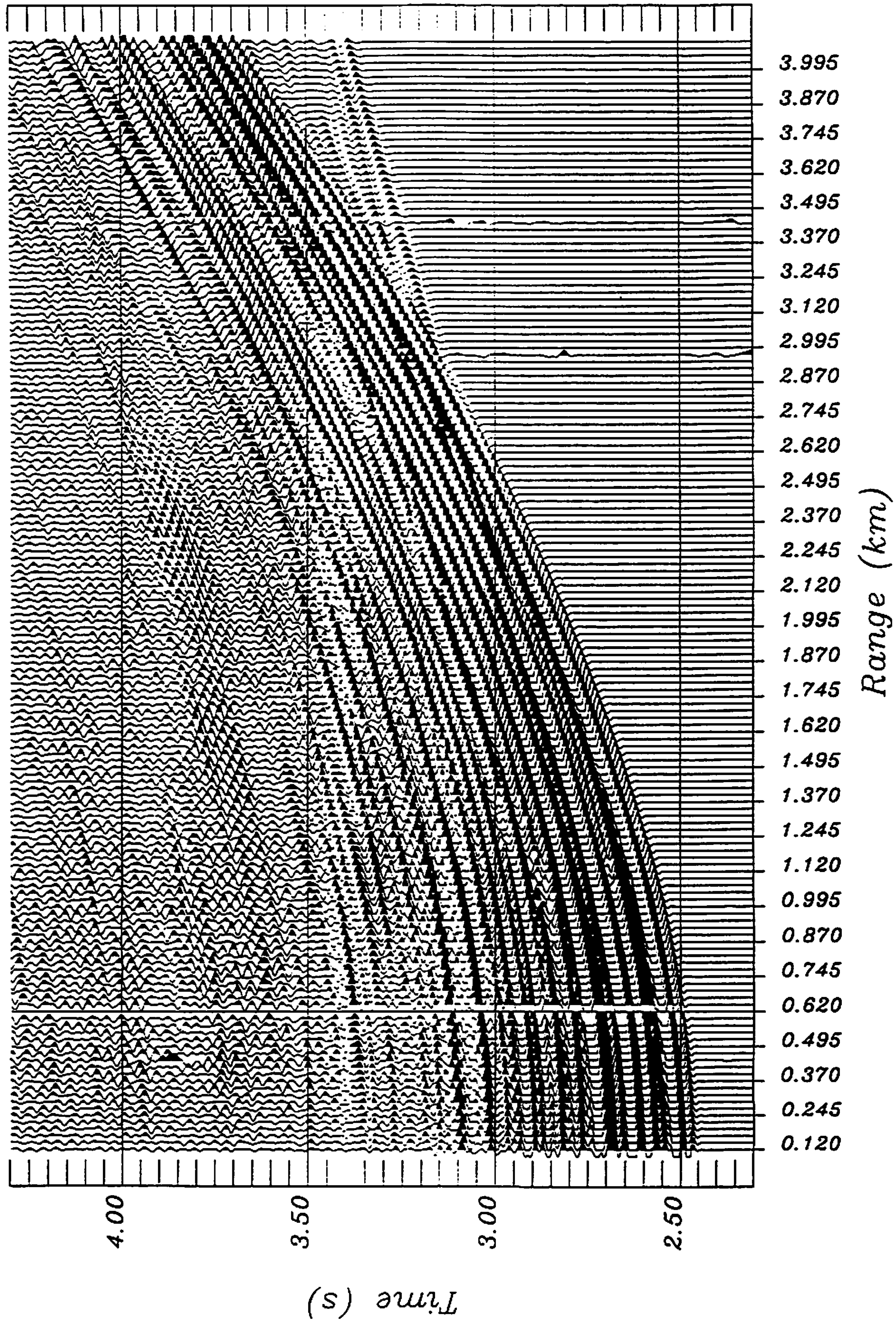
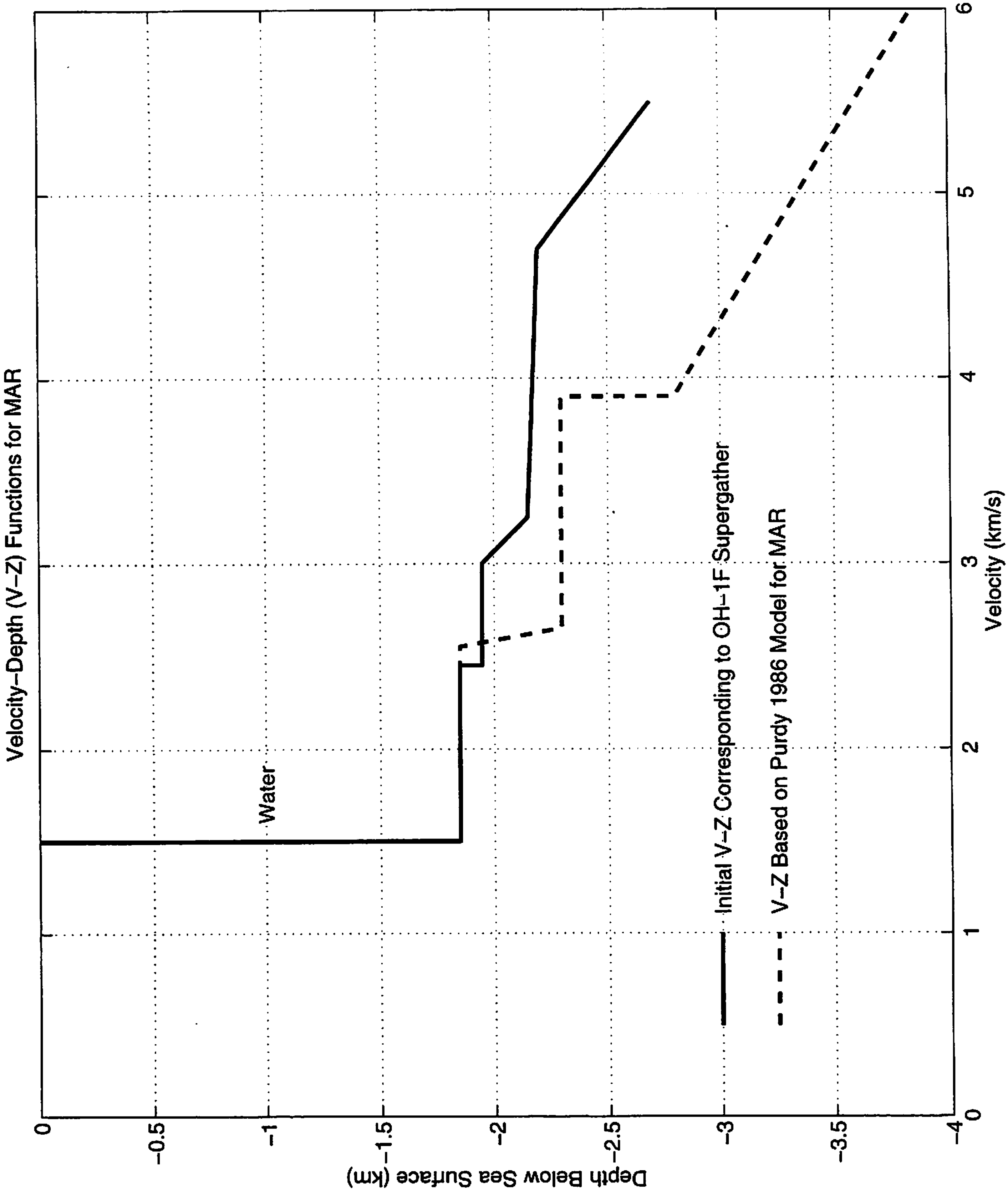


Figure 10



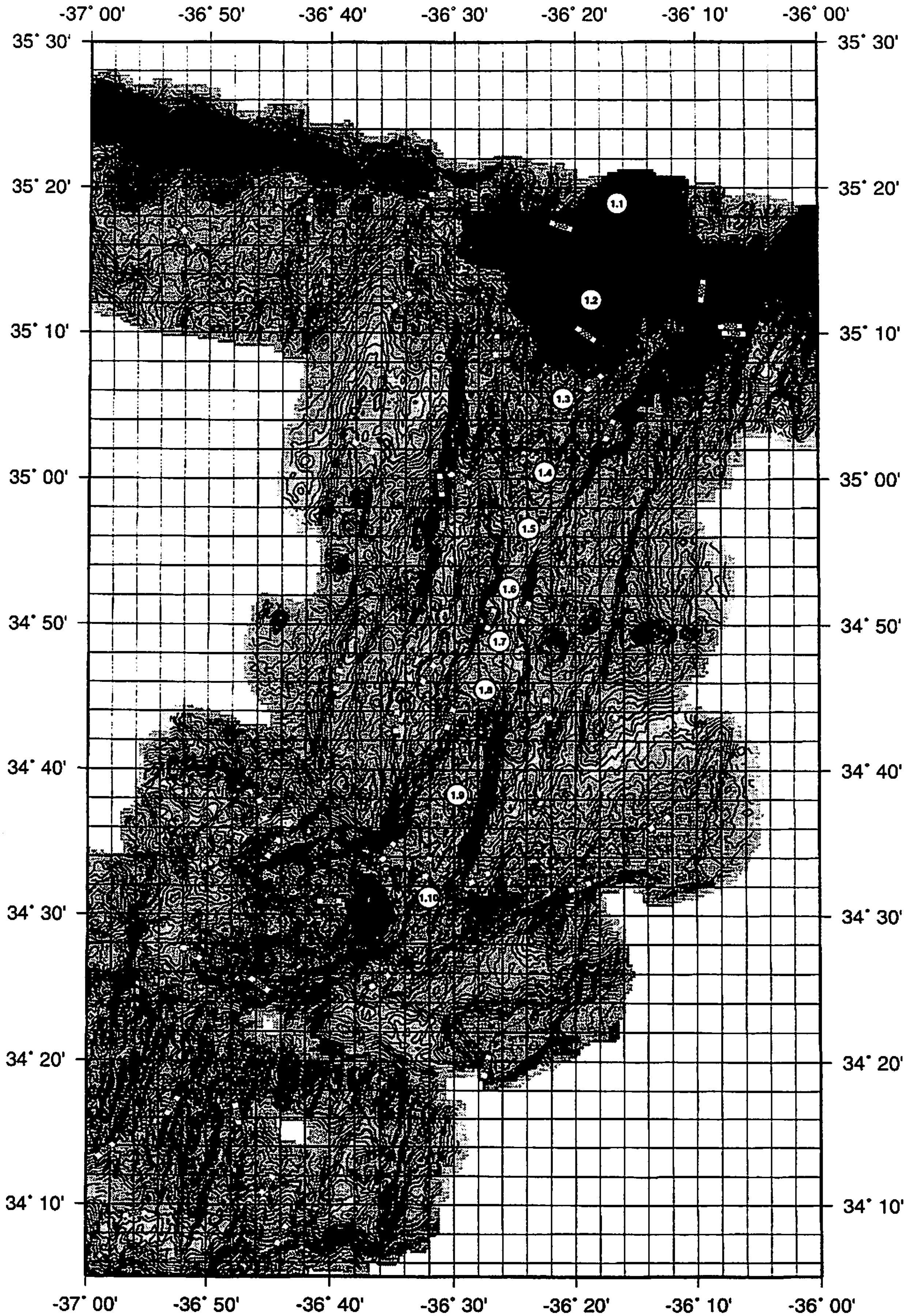
Velocity–Depth (V–Z) Functions for MAR
Water
Initial V–Z Corresponding to OH–1F Supergather
V–Z Based on Purdy 1986 Model for MAR
Velocity (km/s)
Depth Below Sea Surface (km)
0
1
2
3
4
5
6
0
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−4

Figure 11

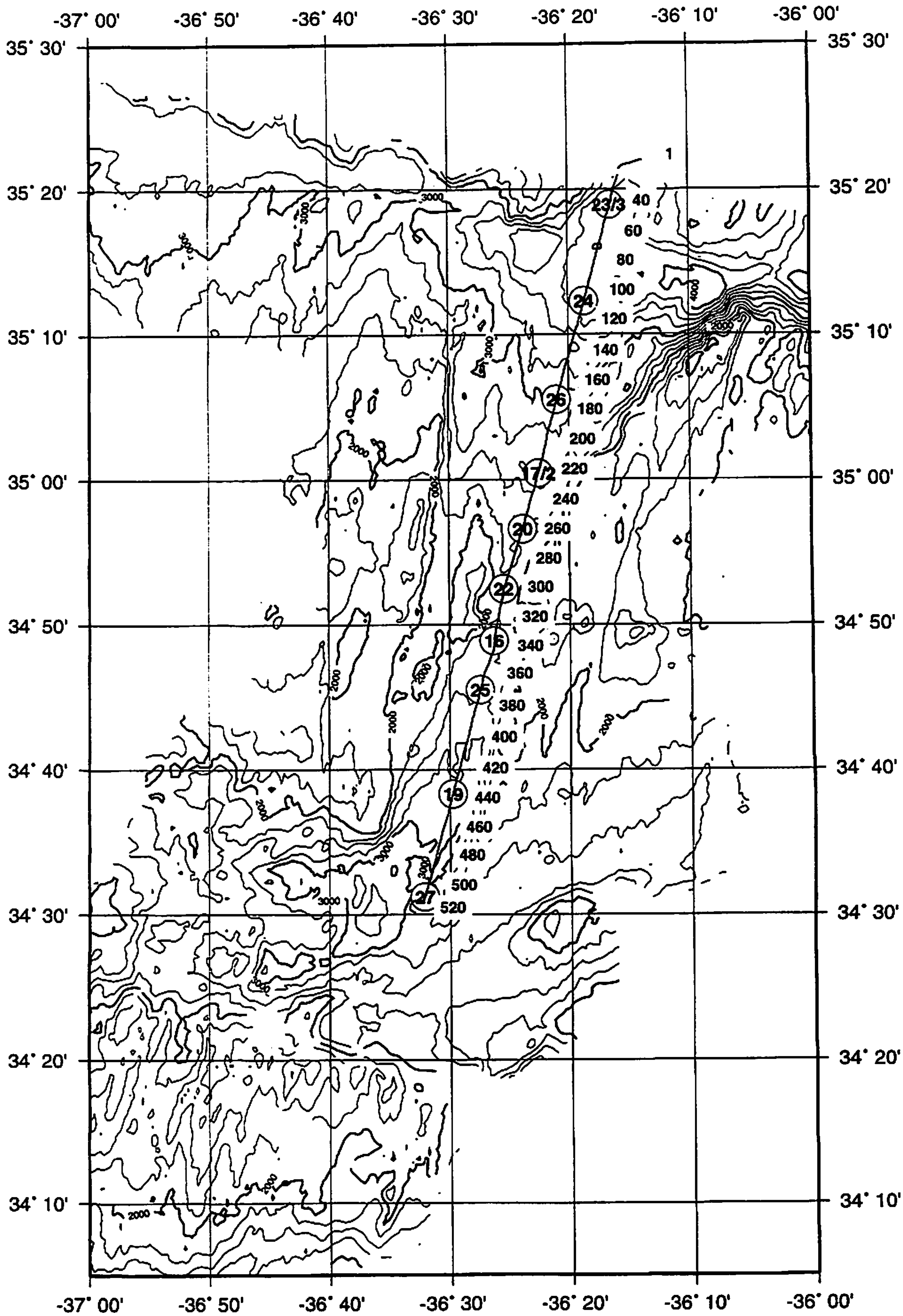
Appendix 1

EW 96-08 Deployment #1 Summary

BULLSEYE Cruise Study Area, Deployment 1 by STA



BULLSEYE Cruise Study Area, Shot Points During Airgun Line #1



Bull's Eye Experiment Deployment #1 Summary

Site #	Instr.	Instr. Drop Location	Instr. Depth (m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Time/Date
First Shot					0001	0902Z 19 Oct. 96
1.1	OBH23	35° 18.914'N 36° 16.505'W	3831	1635Z 18 Oct./0014Z 21 Oct.	0038	0959Z 19 Oct. 96
1.1	ORB3		3826	1635Z 18 Oct./2237Z 20 Oct.		
1.2	OBH24	35° 12.280'N 36° 18.637'W	3832	1740Z 18 Oct./1948Z 20 Oct.	0103	1136Z 19 Oct. 96
1.3	OBH26	35° 05.538'N 36° 20.979'W	2898	1840Z 18 Oct./1710Z 20 Oct.	0170	1316Z 19 Oct. 96
1.4	OBH17	35° 00.412'N 36° 22.532'W	2494	1948Z 18 Oct./1450Z 20 Oct.	0219	1430Z 19 Oct. 96
1.4	ORB2		2489	1948Z 18 Oct./1340Z 20 Oct.		
1.5	OBH20	34° 56.616'N 36° 23.870'W	2224	2033Z 18 Oct./1123Z 20 Oct.	0256	1525Z 19 Oct. 96
1.6	OBH22	34° 52.668'N 36° 25.638'W	2198	2123Z 18 Oct./0938Z 20 Oct.	0289	1627Z 19 Oct. 96
1.7	OBH16	34° 48.892'N 36° 26.295'W	2233	2200Z 18 Oct./0801Z 20 Oct.	0333	1720Z 19 Oct. 96
1.8	OBH25	34° 45.402'N 36° 27.468'W	2545	2248Z 18 Oct./0623Z 20 Oct.	0366	1810Z 19 Oct. 96
1.9	OBH19	34° 38.314'N 36° 29.801'W	2864	2355Z 18 Oct./0418Z 20 Oct.	0434	1952Z 19 Oct. 96
1.10	OBH27	34° 31.190'N 36° 32.111'W	2885	0105Z 19 Oct./0134Z 20 Oct.	0505	2138Z 19 Oct. 96
Last Shot					0547	2300Z 19 Oct. 96

Fixes are from Ashtech GLONASS receiver

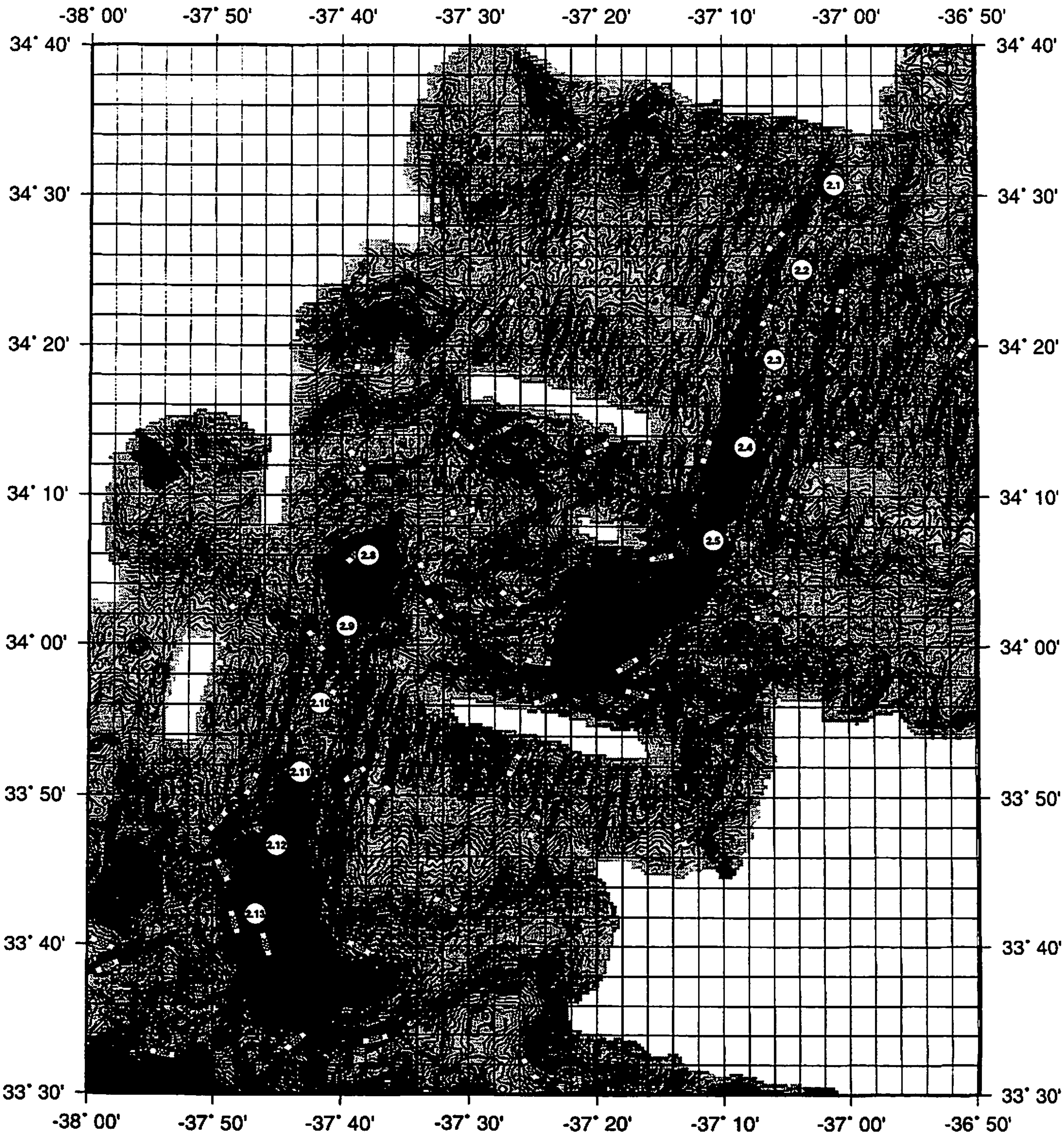
The OBH were floated ~5 m above the seafloor with the hydrophone sensor ~6 m above the seafloor; the two ORBs were tethered 5 m above the OBH or ~11 m above the bottom; depths are instrument depths. All instruments were programmed to turn on at 0900Z on 19 October and ORB 2 and 3 turned off at 2300Z 19 October; OBH and ORB sample rates are 200 samples/sec.

Source: 20-gun, 8420 cu. in. airgun array; 90 sec firing rate for shots 1-508; 120 sec for shots 509-547; gun depth ~10-12 m

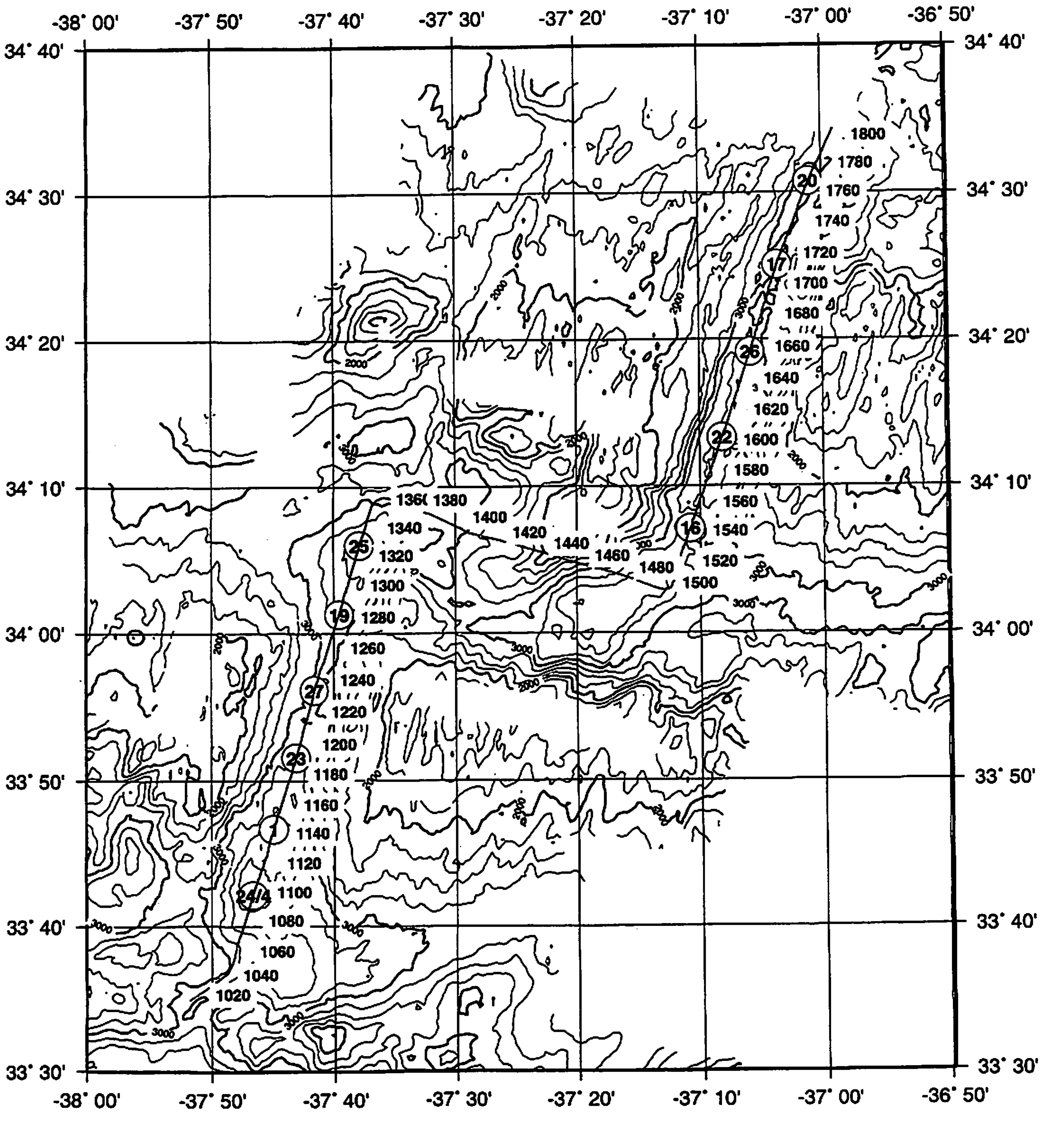
Appendix 2

EW 96-08 Deployment #2 Summary

BULLSEYE Cruise Study Area, Deployment 2 by STA



BULLSEYE Cruise Study Area, Shot Points During Airgun Line #2



Bull's Eye Experiment Deployment #2 Summary

Site #	Instr.	Instr. Drop Location		Instr. Depth (m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Time/Date
Last Shot						1808	2340Z 22 Oct. 96
2.1	OBH20	34° 30.744'N	37° 01.075'W	2953	0842Z 21 Oct./0244Z 23 Oct.	1770	2243Z 22 Oct. 96
2.2	OBH17	34° 25.086'N	37° 03.704'W	2959	1039Z 21 Oct./0508Z 23 Oct.	1716	2122Z 22 Oct. 96
2.3	OBH26	34° 19.110'N	37° 05.898'W	3111	1211Z 21 Oct./0724Z 23 Oct.	1660	1958Z 22 Oct. 96
2.4	OBH22	34° 13.298'N	37° 08.216'W	3268	1348Z 21 Oct./0957Z 23 Oct.	1606	1837Z 22 Oct. 96
2.5	OBH16	34° 07.142'N	37° 10.829'W	3195	1511Z 21 Oct./1300Z 23 Oct.	1545	1706Z 22 Oct. 96
2.8	OBH25	34° 06.007'N	37° 37.907'W	3567	1834Z 21 Oct./1717Z 23 Oct.	1331	1145Z 22 Oct. 96
2.9	OBH19	34° 01.289'N	37° 39.566'W	3165	1948Z 21 Oct./1947Z 23 Oct.	1284	1034Z 22 Oct. 96
2.10	OBH27	33° 56.142'N	37° 41.620'W	3036	2127Z 21 Oct./2157Z 23 Oct.	1236	0922Z 22 Oct. 96
2.11	OBH23	33° 51.582'N	37° 43.166'W	3356	2300Z 21 Oct./0020Z 24 Oct.	1194	0819Z 22 Oct. 96
2.12	ORB1	33° 46.715'N	37° 44.980'W	3701	0019Z 22 Oct./0323Z 24 Oct.	1146	0707Z 22 Oct. 96
2.13	OBH24	33° 42.131'N	37° 46.673'W	3795	0128Z 22 Oct./0559Z 24 Oct.	1103	0603Z 22 Oct. 96
2.13	ORB4			3790	0128Z 22 Oct./0728Z 24 Oct.		
First Shot						1048	0352Z 22 Oct. 96

Fixes are from Ashtech GLONASS receiver; sites 2.6 and 2.7 were not occupied

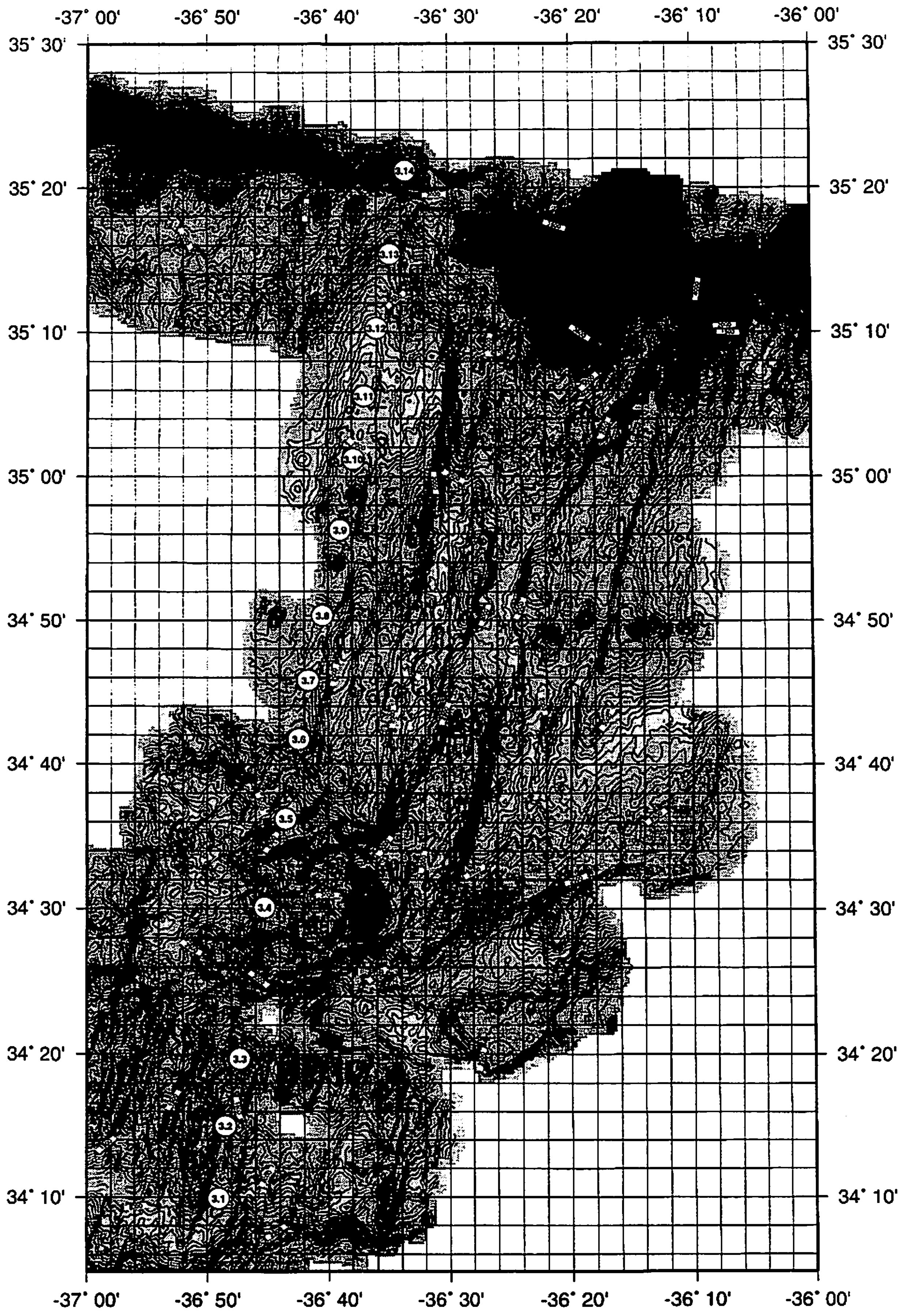
The OBH were floated ~5 m above the seafloor with the hydrophone sensor ~6 m above the seafloor; ORB4 was teathered 5 m above the OBH or ~11 m above the bottom; depths are instrument depths. The OBH were programmed to turn on at 2300Z on 21 October; ORB1 and 4 at 0200Z 22 Oct. ORB1 and 4 turned off at 0200Z 23 Oct.; OBH and ORB sample rates are 200 samples/sec.

Source: 20-gun, 8420 cu. in. airgun array; 90 sec firing rate; gun depth was ~14-16 m

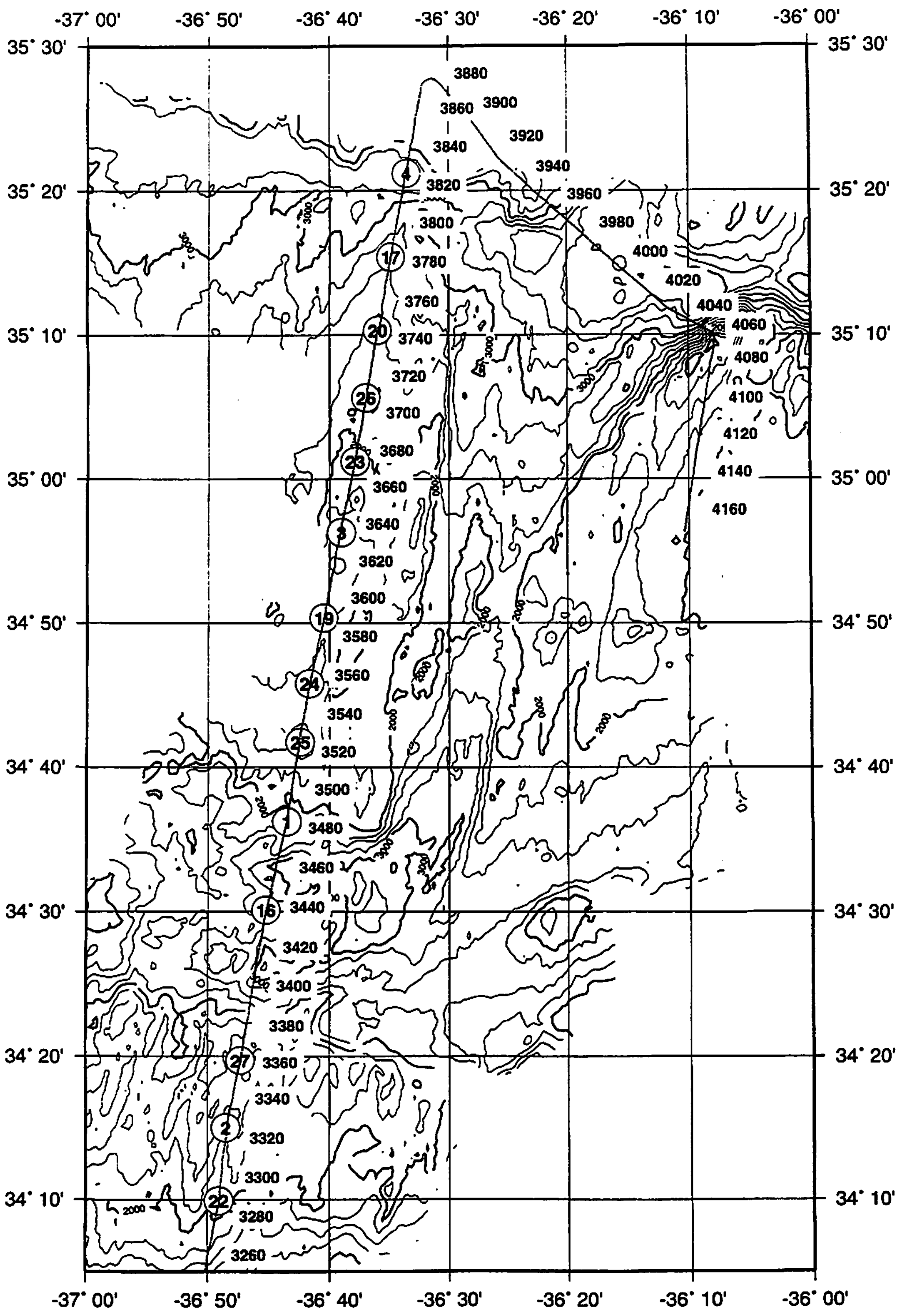
Appendix 3

EW 96-08 Deployment #3 Summary

BULLSEYE Cruise Study Area, Deployment 3 by STA



BULLSEYE Cruise Study Area, Shot Points During Airgun Line #3



Bull's Eye Experiment Deployment #3 Summary

Site #	Instr.	Instr. Drop Location	Instr. Depth (m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Time/Date
First Shot					3241	1702Z 26 Oct. 96
3.1	OBH22	34° 09.928'N 36° 49.072'W	1961	1528Z 24 Oct./1121Z 28 Oct.	3290	1841Z 26 Oct. 96
3.2	ORB2	34° 14.989'N 36° 48.522'W	1730	1627Z 24 Oct./1304Z 28 Oct.	3328	1956Z 26 Oct. 96
3.3	OBH27	34° 19.677'N 36° 47.352'W	1252	1741Z 24 Oct./1411Z 28 Oct.	3364	2107Z 26 Oct. 96
3.4	OBH16	34° 30.100'N 36° 45.234'W	2539	1925Z 24 Oct./1627Z 28 Oct.	3441	2341Z 26 Oct. 96
3.5	ORB1	34° 36.250'N 36° 43.535'W	2342	2030Z 24 Oct./1841Z 28 Oct.	3486	0111Z 27 Oct. 96
3.6	OBH25	34° 41.736'N 36° 42.453'W	1484	2143Z 24 Oct./2005Z 28 Oct.	3528	0235Z 27 Oct. 96
3.7	OBH24	34° 45.820'N 36° 41.677'W	1537	2254Z 24 Oct./2119Z 28 Oct.	3558	0336Z 27 Oct. 96
3.8	OBH19	34° 50.347'N 36° 40.468'W	1729	2356Z 24 Oct./2236Z 28 Oct.	3592	0444Z 27 Oct. 96
3.9	ORB3	34° 56.297'N 36° 39.023'W	1672	0107Z 25 Oct./0103Z 29 Oct.	3638	0616Z 27 Oct. 96
3.10	OBH23	35° 01.200'N 36° 37.899'W	1947	0217Z 25 Oct./0233Z 29 Oct.	3677	0734Z 27 Oct. 96
3.11	OBH26	35° 05.631'N 36° 36.984'W	2022	0324Z 25 Oct./0406Z 29 Oct.	3711	0841Z 27 Oct. 96
3.12	OBH20	35° 10.337'N 36° 36.030'W	2153	0437Z 25 Oct./0544Z 29 Oct.	3747	0954Z 27 Oct. 96
3.13	OBH17	35° 15.420'N 36° 34.899'W	2481	0545Z 25 Oct./0730Z 29 Oct.	3785	1110Z 27 Oct. 96
3.14	ORB4	35° 21.190'N 36° 33.556'W	3274	0653Z 25 Oct./lost	3838	1236Z 27 Oct. 96
Last Shot *					3855	1330Z 27 Oct. 96

Line 3A shot from 1702Z 26 Oct. 96 - 1330Z 27 Oct. 96 along from south to north; line 3B in eastern rift mts shot from . 2031Z 27 Oct (shot # 4065) to 0542Z 28 Oct. 96 (shot #4341) north to south. Aborted shooting line from 0932Z(#3003) to 1600Z(#3197) on Oct. 25 shot from north to south

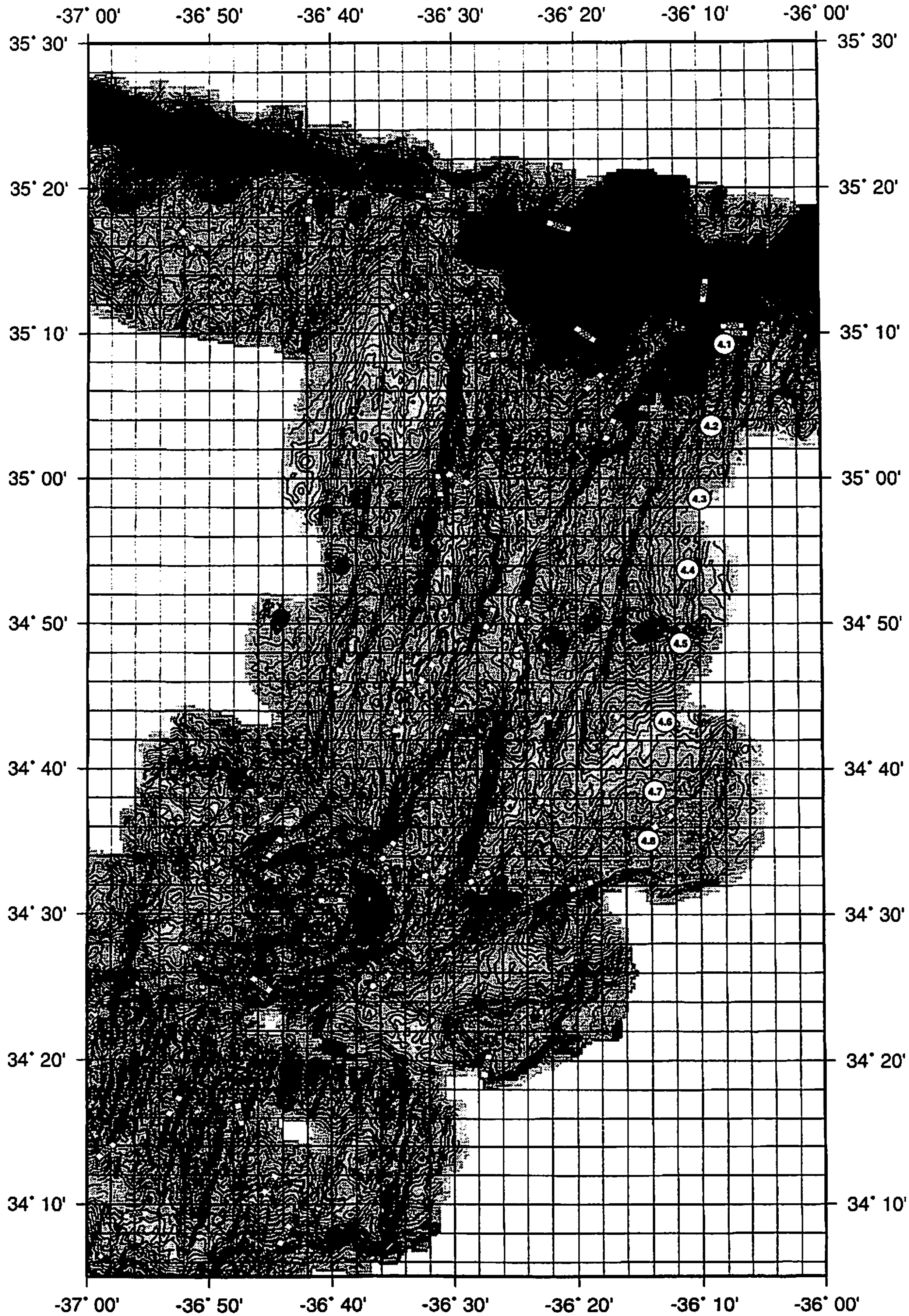
Fixes are from Ashtech GLONASS receiver, source: 20-gun, 8420 cu. in. airgun array; 120 sec firing rate; gun depth was ~10 m

The OBH hydrophone sensor is ~6 m above the seafloor; the ORBs are ~5 m above the sea floor. All instruments were programmed to turn on at 0500Z on 25 Oct.; ORBs 3&4 turned off at 1500Z 26 Oct.; OBH and ORB sample rates are 200 samples/sec

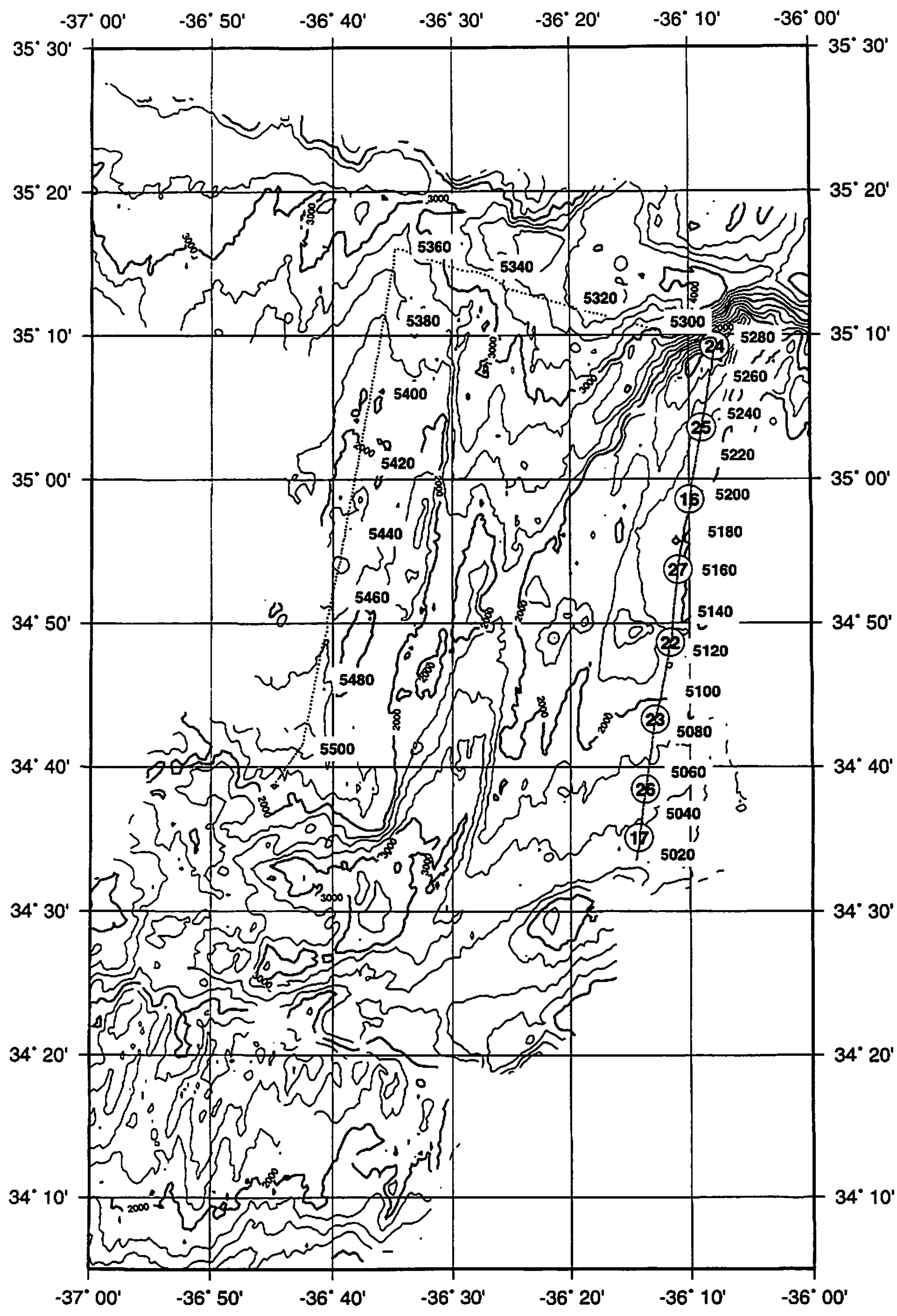
Appendix 4

EW 96-08 Deployment #4 Summary

BULLSEYE Cruise Study Area, Deployment 4 by STA



BULLSEYE Cruise Study Area, Shot Points During Airgun Line #4



Bull's Eye Experiment Deployment #4 Summary

Site #	Instr.	Instr. Drop Location		Instr. Depth (m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Time/Date
Last Shot						5279	2130Z 30 Oct. 96
4.1	OBH24	35° 09.219'N	36° 07.853'W	1192	0148Z 30 Oct./0449Z 1 Nov.	5278	2128Z 30 Oct. 96
4.2	OBH25	35° 03.608'N	36° 08.985'W	1789	0320Z 30 Oct./0322Z 1 Nov.	5236	2003Z 30 Oct. 96
4.3	OBH16	34° 58.594'N	36° 09.981'W	1967	0436Z 30 Oct./0147Z 1 Nov.	5200	1851Z 30 Oct. 96
4.4	OBH27	34° 53.721'N	36° 10.936'W	1875	0559Z 30 Oct./0009Z 1 Nov.	5163	1737Z 30 Oct. 96
4.5	OBH22	34° 48.680'N	36° 11.566'W	1842	0716Z 30 Oct./2230Z 31 Oct.	5127	1625Z 30 Oct. 96
4.6	OBH23	34° 43.296'N	36° 12.886'W	2218	0832Z 30 Oct./2041Z 31 Oct.	5088	1459Z 30 Oct. 96
4.7	OBH26	34° 38.495'N	36° 13.710'W	2407	0934Z 30 Oct./1854Z 31 Oct.	5054	1401Z 30 Oct. 96
4.8	OBH17	34° 35.108'N	36° 14.257'W	2573	1048Z 30 Oct./1705Z 31 Oct.	5031	1313Z 30 Oct. 96
First Shot						5015	1245Z 30 Oct. 96

Line 4A shot from 1211Z 30 Oct. 96 (#5000) - 2130Z 30 Oct. 96 (#5279) from south to north in eastern rift mts of segment OH-1; line 4B shot from north to south in western rift mts of segment OH-1 between 0243 31 Oct. 96(#5361) - 1139Z 31 Oct. 96 (#5495).

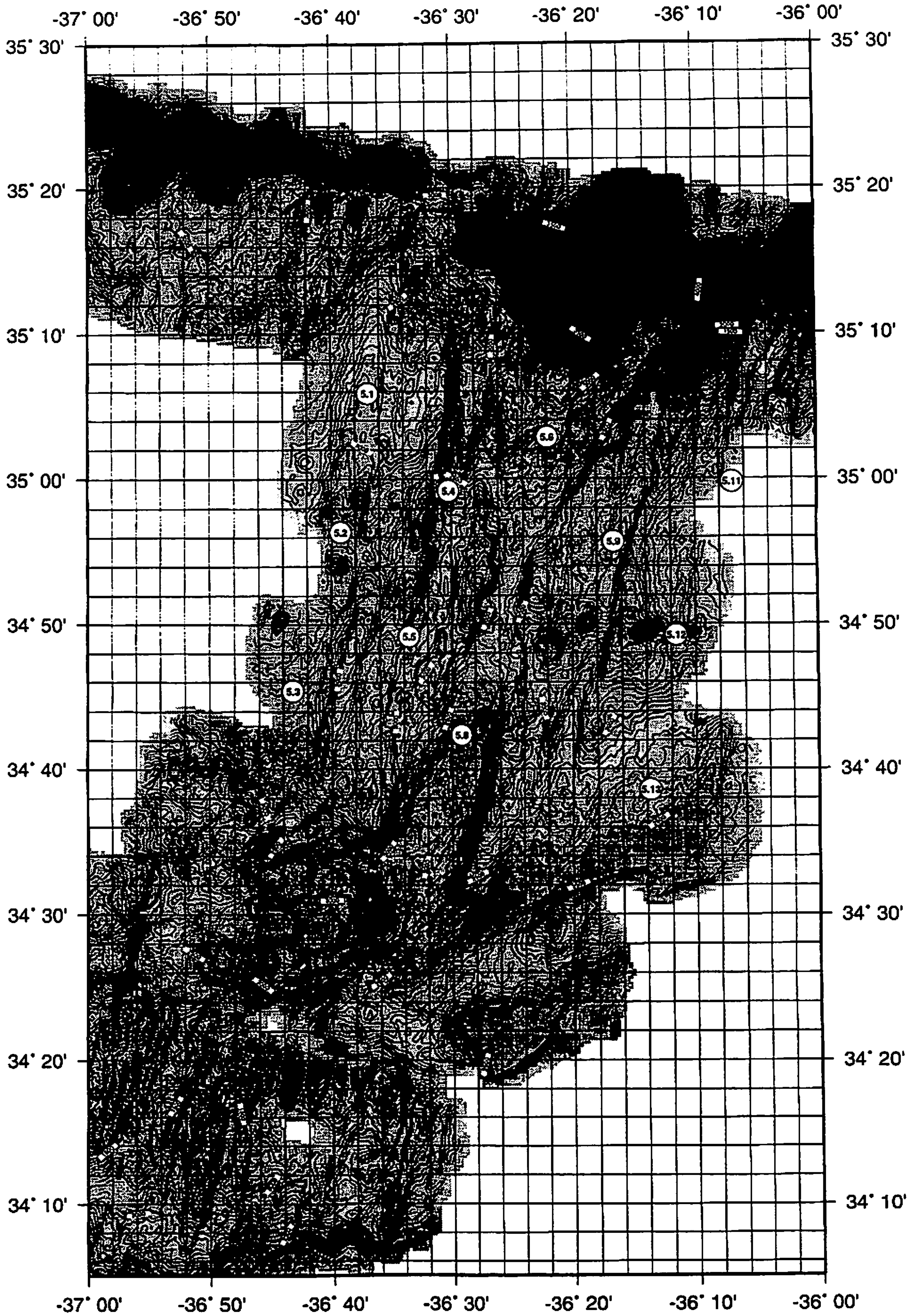
Fixes are from Ashtech GLONASS receiver, source: 20-gun, 8420 cu. in. airgun array; 120 sec firing rate on line 4A; 240 s on line 4B; gun depth was ~10 m but quite variable as the seas were very high

The OBH hydrophone sensor is ~6 m above the seafloor. All instruments were programmed to turn on at 1100Z on 30 Oct.; sample rates are 200 samples/sec

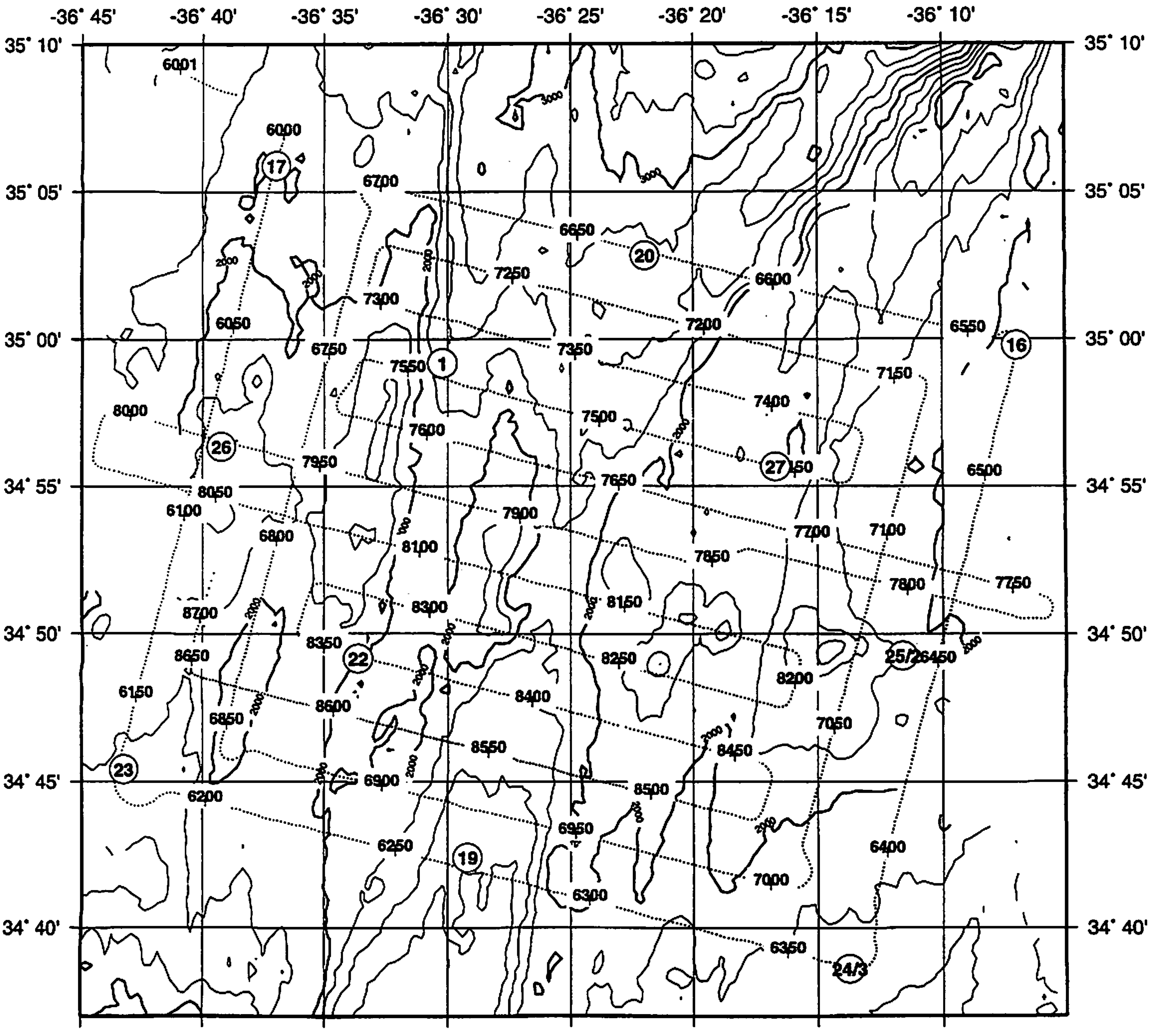
Appendix 5

EW 96-08 Deployment #5 Summary

BULLSEYE Cruise Study Area, Deployment 5 by STA



BULLSEYE Cruise Study Area, Shot Points During OH-1 Tomography



Bull's Eye Experiment Deployment #5 Summary

Site #	Instr.	Instr. Drop Location	Instr. Depth (m)	Deployment/Recovery Time	Shot #	Time
First Shot					6000	0508Z 7 Nov. 96
5.1	OBH17	35° 05.885'N 36° 36.943'W	2047	1050Z 06 Nov./2016Z 11 Nov.		
5.2	OBH26	34° 56.365'N 36° 39.231'W	1681	0938Z 06 Nov./2215Z 11 Nov.		
5.3	OBH23	34° 45.401'N 36° 43.250'W	1610	0816Z 06 Nov./0011Z 12 Nov.		
5.4	ORB1	34° 59.199'N 36° 30.220'W	2376	1827Z 06 Nov./1817Z 11 Nov.		
5.5	OBH22	34° 49.157'N 36° 33.585'W	1925	0703Z 06 Nov./0034Z 11 Nov.		
5.6	OBH20	35° 02.842'N 36° 21.962'W	2717	1218Z 06 Nov./1603Z 11 Nov.		
5.8	OBH19	34° 42.382'N 36° 29.203'W	2789	0555Z 06 Nov./0235Z 11 Nov.		
5.9	OBH27	34° 55.681'N 36° 16.655'W	1964	1321Z 06 Nov./1123Z 11 Nov.		
5.11	OBH16	34° 59.779'N 36° 06.981'W	2053	1426Z 06 Nov./1323Z 11 Nov.		
5.12	OBH25	34° 49.255'N 36° 11.621'W	1887	1545Z 06 Nov./0926Z 11 Nov.		
	ORB2		1873	1545Z 06 Nov./0835Z 11 Nov.		
5.13	OBH24	34° 38.596'N 36° 13.757'W	2402	2245Z 06 Nov./0614Z 11 Nov.		
	ORB3		2388	2245Z 06 Nov./0516Z 11 Nov.		
Last Shot					8706	2214Z 10 Nov. 96

Fixes are from Ashtech GLONASS receiver, source: 20-gun, 8420 cu. in. airgun array; 120 sec firing rate

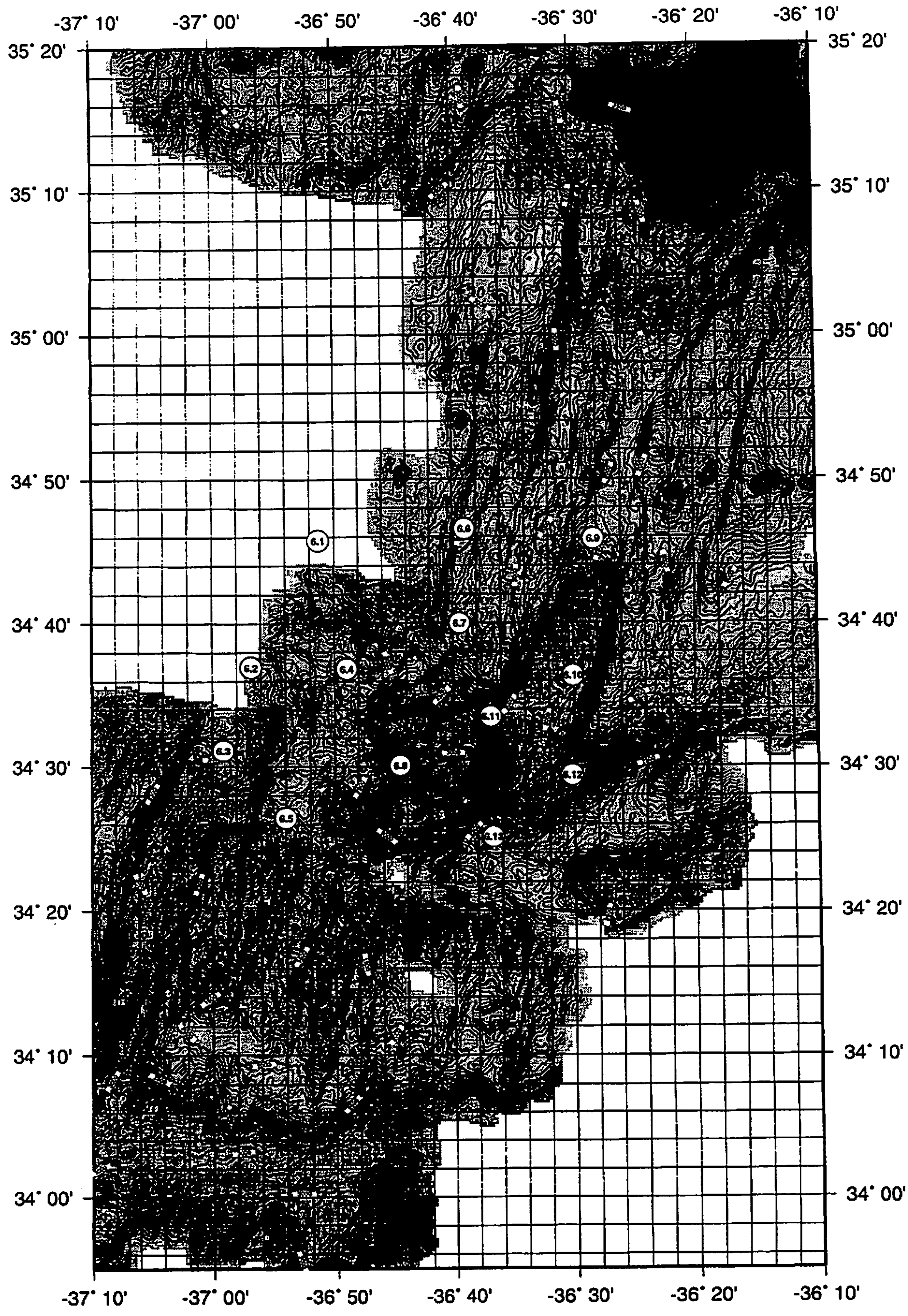
The OBH hydrophone sensor is ~6 m above the seafloor; ORB 1 is ~ 5 m above the seafloor. ORBs 2 and 3 were tethered ~14 m above the OBH. All OBH and ORBs 1 and 2 were programmed to turn on at 0500Z on 7 Nov.; sample rates are 200 samples/sec. The ORBs were programmed to turn off at 0500Z on 11 Nov.

OBH 23 had a faulty hydrophone/hydrophone cable and recorded a very low amplitude signal

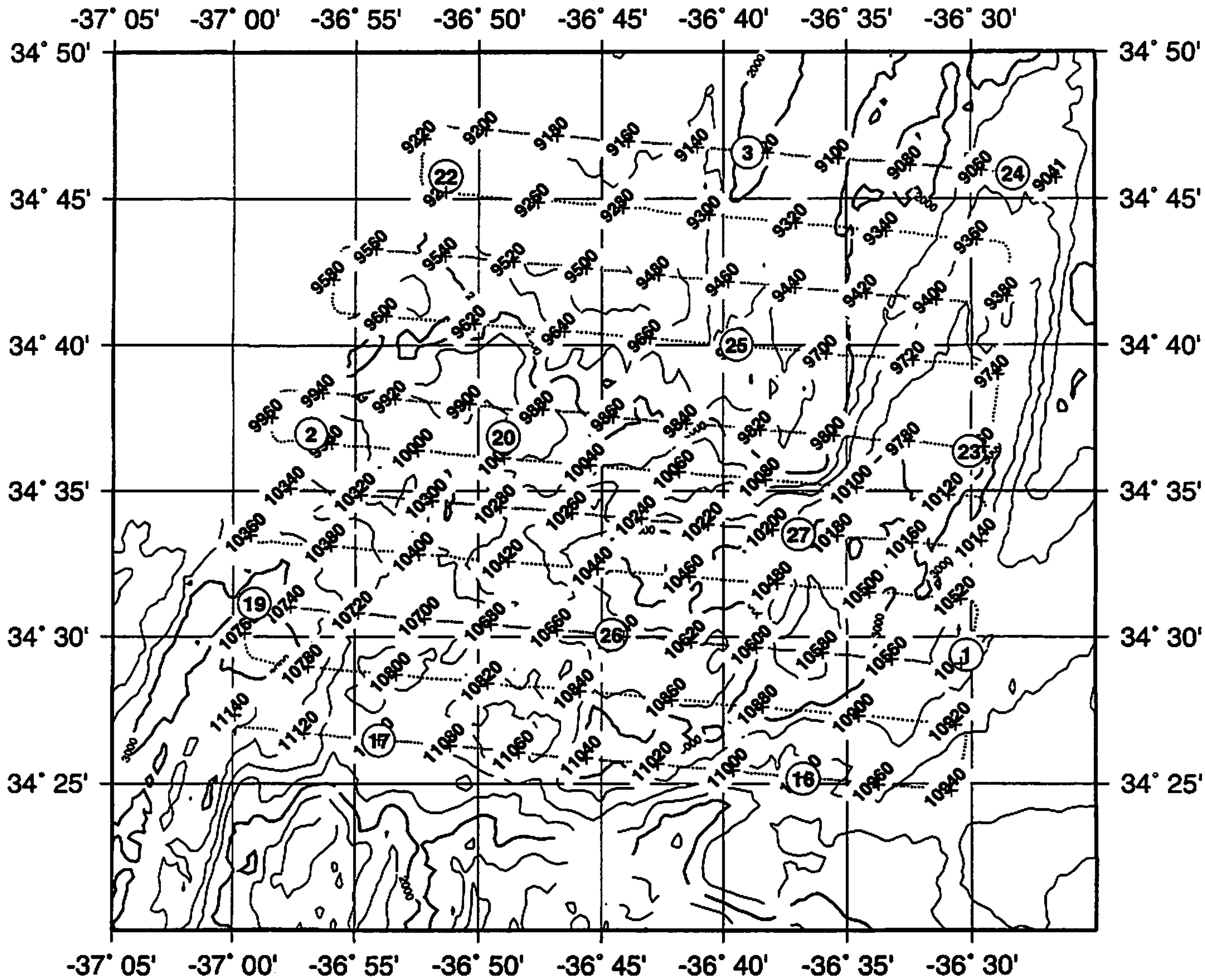
Appendix 6

EW 96-08 Deployment #6 Summary

BULLSEYE Cruise Study Area, Deployment 6 by STA



BULLSEYE Cruise Study Area, Shot Points During NTO Tomography



Bull's Eye Experiment Deployment #6 Summary

Site #	Instr.	Instr. Drop Location		Instr. Depth (m)	Deployment/Recovery Time	Shot #	Time
First Shot						9042	2000Z 12 Nov. 96
6.1	OBH22	34° 45.763'N	36° 51.320'W	1793	0142Z 12 Nov./1207Z 16 Nov.		
6.2	ORB2	34° 36.965'N	36° 56.822'W	2432	0433Z 12 Nov./1547Z 16 Nov.		
6.3	OBH19	34° 31.143'N	36° 59.126'W	3116	0552Z 12 Nov./1735Z 16 Nov.		
6.4	OBH20	34° 36.861'N	36° 48.994'W	2175	0305Z 12 Nov./1353Z 16 Nov.		
6.5	OBH17	34° 26.467'N	36° 54.001'W	2295	0658Z 12 Nov./1948Z 15 Nov.		
6.6	ORB3	34° 46.569'N	36° 39.004'W	2023	1617Z 12 Nov./1020Z 16 Nov.		
6.7	OBH25	34° 40.020'N	36° 39.460'W	1492	1514Z 12 Nov./0620Z 16 Nov.		
6.8	OBH26	34° 30.078'N	36° 44.612'W	2528	0811Z 12 Nov./2137Z 15 Nov.		
6.9	OBH24	34° 45.839'N	36° 28.300'W	2460	1736Z 12 Nov./0820Z 16 Nov.		
6.10	OBH23	34° 36.361'N	36° 30.086'W	2960	1349Z 12 Nov./0446Z 16 Nov.		
6.11	OBH27	34° 33.526'N	36° 36.920'W	3220	1228Z 12 Nov./0304Z 16 Nov.		
6.12	ORB1	34° 29.389'N	36° 30.218'W	2731	1033Z 12 Nov./0104Z 16 Nov.		
6.13	OBH16	34° 25.178'N	36° 36.756'W	2347	0929Z 12 Nov./2316Z 15 Nov.		
Last Shot						11136	1749Z 15 Nov. 96

Fixes are from Ashtech GLONASS receiver, source: 20-gun, 8420 cu. in. airgun array; 120 sec firing rate

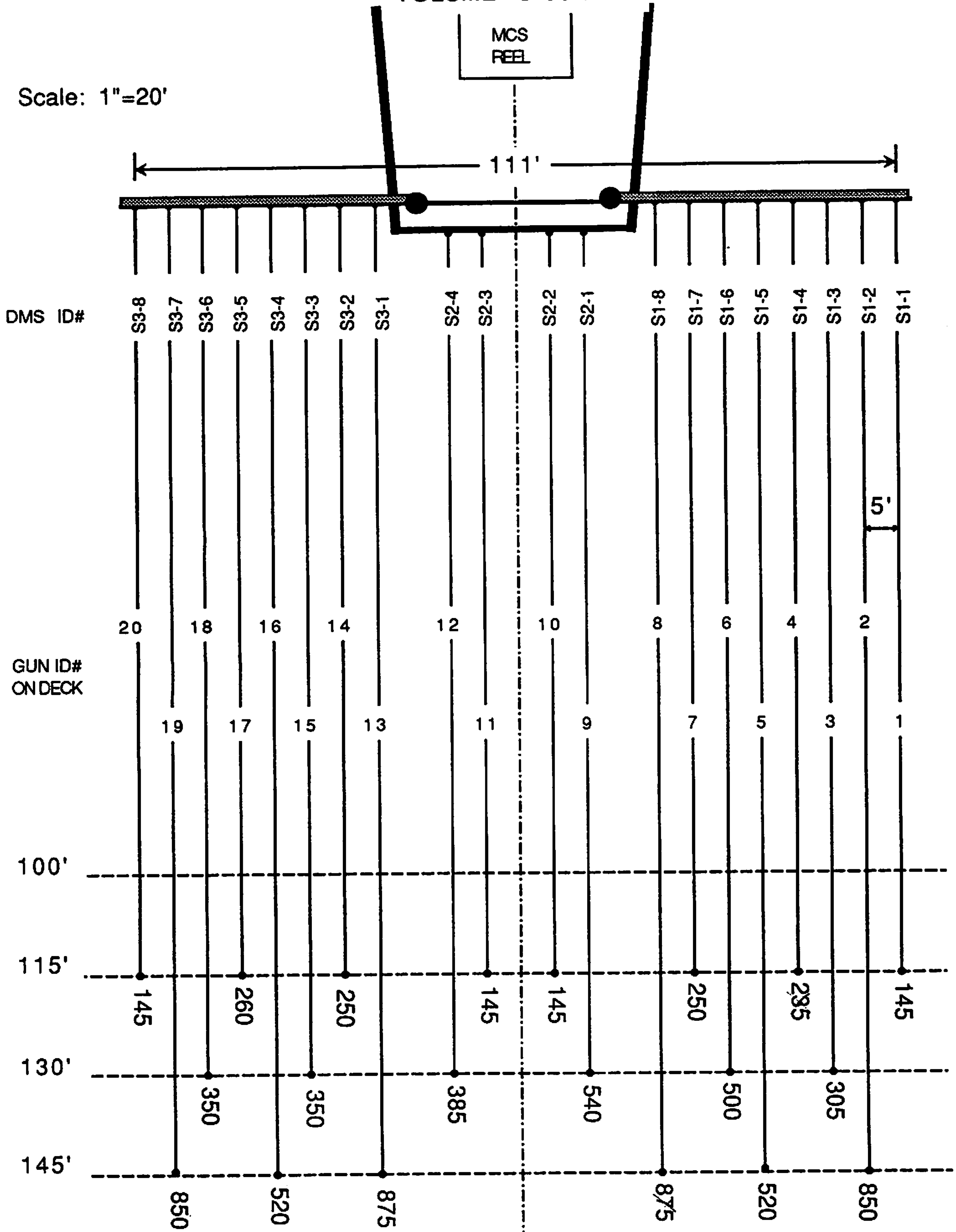
The OBH hydrophone sensor is ~6 m above the seafloor; The ORB hydrophones are ~ 5 m above the seafloor. All OBH and ORBs 1 and 2 were programmed to turn on at 2000Z on 12 Nov.; ORB 3 was in continuous record mode; sample rates are 200 samples/sec. The ORBs were programmed to turn off at 1800Z on 15 Nov.

Appendix 7

Airgun Arrays for Refraction and MCS Shooting

EWING AIRGUN ARRAY- 20 GUN FOR BULLSEYE OBH PROJECT

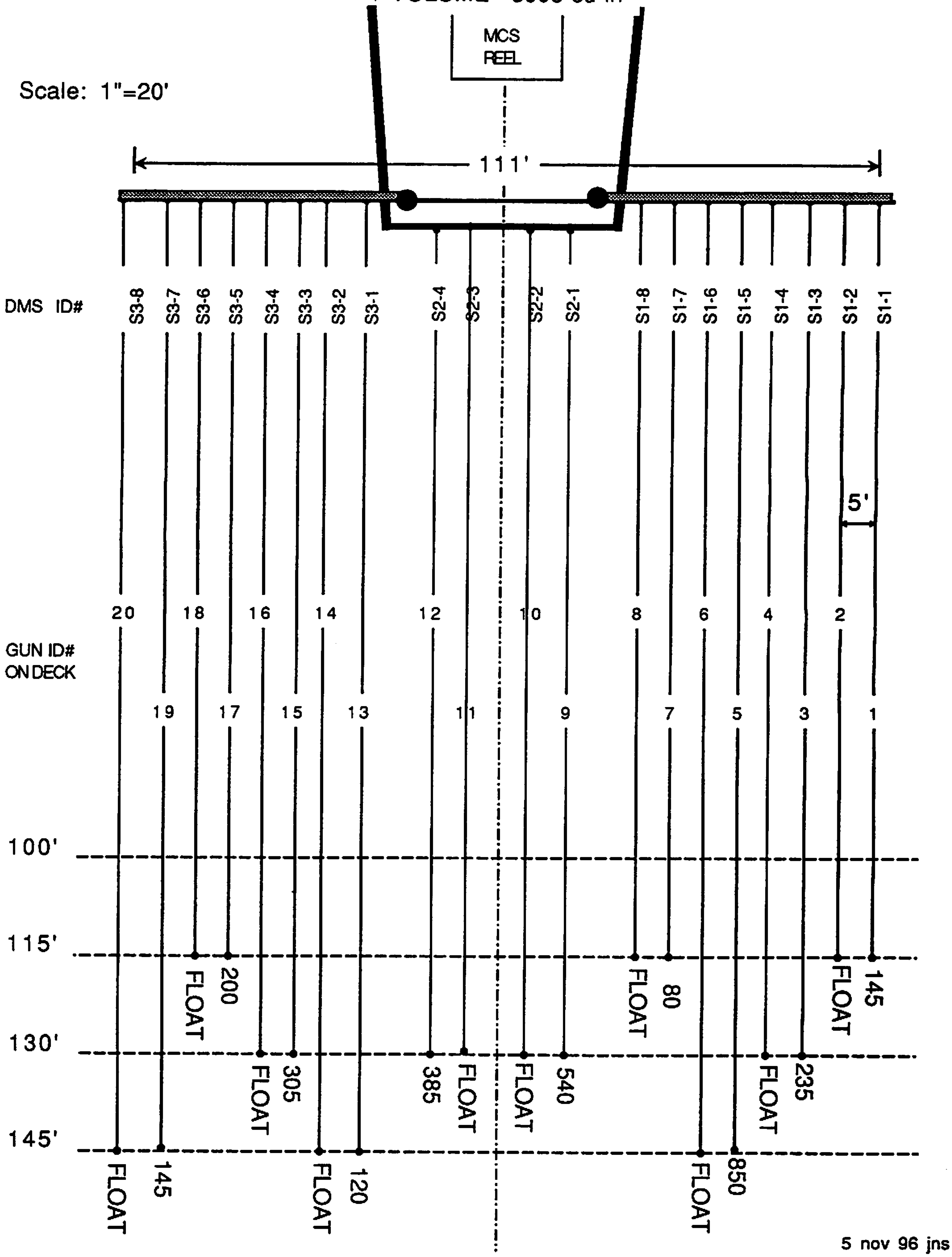
VOLUME= 8495 cu in



27oct96 jns

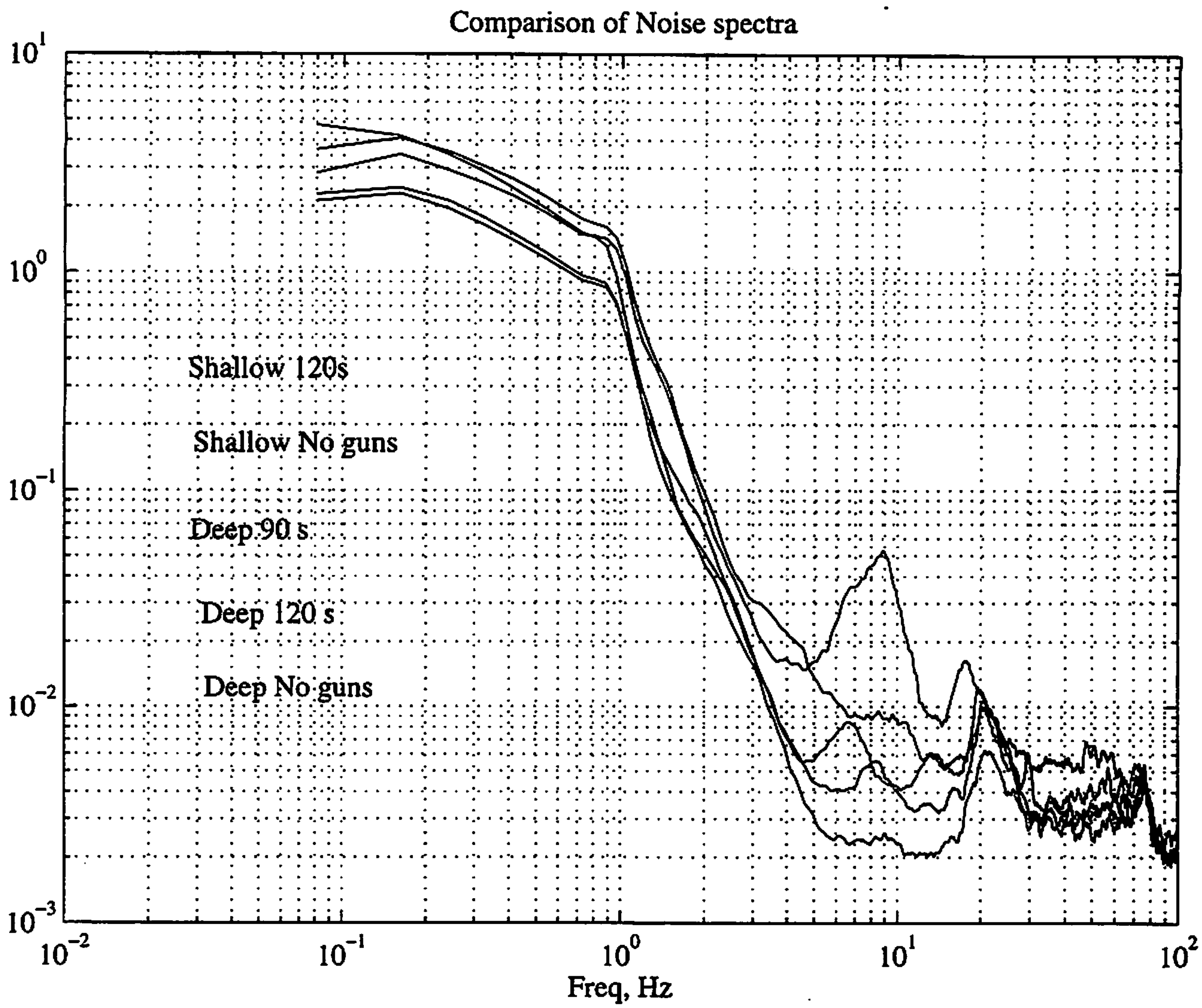
EWING AIRGUN ARRAY- 10 GUN FOR BULLSEYE MCS PROJECT

VOLUME= 3005 cu in



Appendix 8

Noise Spectra for Different Firing Intervals



Comparison of Noise spectra
Shallow 120s
Shallow No guns
Deep 90 s
Deep 120 s
Deep No guns
Freq, Hz
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

Appendix 9
Relocation of OBH on EW 96-08

Accurate locations of the OBHs on the seafloor were determined from the shot positions and water wave travel times to the instruments using an algorithm originally developed by *Creager and Dorman* [1982]. The problem is treated as an overdetermined system of equations which includes the deployment position and depth of the OBH, the ship positions (GPS) for the shots, and the two-way travel time between the ship and the OBHs for the shots. The origin time of the shots is held fixed. We solve for the location and depth of the instrument and the position of each shot. The forward problem is to calculate the acoustic travel times from distances between ship fixes and OBHs and is solved using a ray tracing algorithm. This system of equations is lineralized and transformed to diagonalize the covariances; it is then solved iteratively by inverting the data jointly using a singular value decomposition and step-length damping.

The water wave arrival was picked out to ranges of 10 km from the instrument using the OBH segy record sections. The standard deviation of the travel time observations was 2 ms. The standard deviation of the GLONASS GPS fixes was assumed to be 8 m. The airguns were assumed to be 88 m behind the ship's GPS antenna and this was included in determining the input shot location. Shot depth was set at 8 or 12 m below the sea surface. The standard deviation of the input OBH depth was 40 m.

Since the shots were located along a line in the north-south direction for deployments 1-4, the location of the OBH in the east-west direction was ill-constrained. The water velocity structure used is given in Appendix 18. The water velocity structure used appeared to be somewhat slow since in the solutions there appeared to be a trend of pulling the relocated shot positions in towards the instrument, and a slight tendency of moving the OBH to shallower depths. However, we decided not to invert for water velocity structure and rather assume that the OBH position was correct based on symmetry arguments. The OBH depth should be obtained from the Hydrosweep bathymetry using the relocated position.

For the ray tracing, the water velocity structure is assumed to contain a single waveguide. Only one velocity inversion is allowed and velocity should change monotonically away from this inflection point. In the ray tracing routine the instrument is assumed to lie below the velocity inversion. However, in several deployments the instruments were located within the SOFAR channel, i.e. above the point of lowest velocity. The was dealt with by adding a small velocity notch (-0.02 km/s over 100 m) directly above the instrument. This seemed to be an adequate solution to the problem and the results obtained appeared to be stable.

MARBE1: Correction of OBH Locations:

Corrected using obsloc with parameters:

range_max	= 6;	Maximum allowable fix range in km
big	= 0.008;	Std dev in km of fix (major axis)
erraz	= 0;	Azimuth of major axis
small	= 0.008;	Std dev in km of fix (minor axis)
shot_depth	= 8;	Shot depth in meters
eigen_ratio	= 0.0100;	Acceptable ratio of smallest to largest eigenvalue
iterations	= 5;	Maximum number of iterations allowed
std_obsz	= 0.04;	Standard deviation in prior OBH depth
std_tt	= 0.002;	Standard deviation in travel time observations
		Shots are 88m behind the ships GPS fix.

		Initial			Final			Final - Initial			Error Ellipse		
OBH Site	OBH #	Longitude	Latitude	Depth, km	Longitude	Latitude	Depth, km	dx, m	dy, m	dz, m	1/2 major axis	1/2 minor axis	Azimuth
1.1	23	-36.2751	35.3152	3.831	-36.2748	35.3159	3.816	28	73	-15	16	4	15
1.2		-36.3106	35.2047	3.832	-36.3102	35.2058	3.819	40.	123	-13	15	2	15
1.3		-36.3496	35.0923	2.898	-36.3495	35.0925	2.904	6	17	6	14	4	13
1.4		-36.3755	35.0069	2.494	-36.3753	35.0074	2.480	17	57	-14	14	3	17
1.5		-36.3978	34.9436	2.224	-36.3976	34.9441	2.227	17	55	3	15	2	16
1.6		-36.4273	34.8778	2.198	-36.4221	34.8732	2.183	582	-512	-15	300	14	104.
1.7		-36.4382	34.8149	2.233	-36.4359	34.8150	2.191	251	16	-42	188	13	101
1.8		-36.4578	34.7567	2.545	-36.4575	34.7575	2.501	36	84	-44	14	4	12
1.9		-36.4967	34.6386	2.864	-36.4965	34.6393	2.845	25	81	-19	14	2	15
1.10		-36.5352	34.5198	2.885	-36.5350	34.5225	2.894	17	300	9	59	13	111

MARBE2: Correction of OBH Locations:

Corrected using obsloc with parameters:

range_max = 6;	Maximum allowable fix range in km
big = 0.008;	Std dev in km of fix (major axis)
erraz = 0;	Azimuth of major axis
small = 0.008;	Std dev in km of fix (minor axis)
shot_depth = 8;	Shot depth in meters
eigen_ratio = 0.0100;	Acceptable ratio of smallest to largest eigenvalue
iterations = 5;	Maximum number of iterations allowed
std_obsz = 0.04;	Standard deviation in prior OBH depth
std_tt = 0.002;	Standard deviation in travel time observations
	Shots are 88m behind the ships GPS fix.

		Initial			Final			Final - Initial			Error Ellipse		
OBH Site	OBH #	Longitude	Latitude	Depth, km	Longitude	Latitude	Depth, km	dx, m	dy, m	dz, m	1/2 major axis	1/2 minor axis	Azimuth
2.1		-37.0179	34.5124	2.953	-37.0173	34.5136	2.950	61	132	-3	15	1	22
2.2		-37.0617	34.4181	2.959	-37.0612	34.4193	3.036	55	132	77	17	3	18
2.3		-37.0983	34.3185	3.111	-37.0979	34.3194	3.078	41	105	-33	15	2	18
2.4		-37.1369	34.2216	3.268	-37.1363	34.2229	3.269	62	148	1	16	2	21
2.5		-37.1805	34.1190	3.195	-37.1801	34.1199	3.215	42	1009	20	15	3	18
2.8		-37.6318	34.1001	3.567	-37.6314	34. 1013	3.567	50	138	0	15	3	15
2.9		-37.6594	34.0215	3.165	-37.6588	34.0232	3.169	72	191	4	17	2	17
2.10		-37.6877	33.9357	3.036	-37.6878	33.9360	2.977	-11	28	-59	15	5	15
2.11		-37.7194	33.8597	3.356	-37.7188	33.8613	3.343	62	176	-13	15	2	16
2.13		-37.7779	33.7022	3.795	-37.7775	33.7032	3.797	41	112	2	16	3	16

Appendix 10

OBH Configurations and Performance Summary

Table A10-1

EW96-08
OBH FRAME CONFIGURATION

OBH	EID	9 kHz Release	11 kHz Release	Flasher #1	Flasher #2	Radio	Freq.	Hydrophone	Leads
16	16	14748	14148	F03013	18110	18042	159.480 (B)	GF-15 (M)	23BB
17	17	18332	14159	F03010	18111	18048	160.725 (C)	1385 (B)	36BM
19	19	14511	14153	18078	18065	18051	160.725 (C)	GF-13 (M)	33BM
20	20	14737	14164	F03015	18089	18053	160.725 (C)	151 (B)	30BM
22	22	14745	14129	18077	18106	18052	160.725 (C)	GF-6 (B)	21BB
23	23	14118	14125	18123	18117	18054	160.785 (D)	GF-7 (M)	39BM
24	24	14113	14160	18121	18068	18033	154.585 (A)	GF-11 (M)	35BM
25	25	14738	14152	18107	18112	18046	160.725 (C)	G10 (M)	15BB
26	26	14734	14157	105787	F03007	18038	159.480 (B)	GF-9 (B)	37BM
27	27	13653	14150	18080	18118	G04001	159.480 (B)	GF-2 (M)	31BM

For hydrophone leads BB is Burton to OBH, Burton to hydrophone;
BM is Burton to OBH, Mecca to hydrophone.

Prior to MARBE1, the S/N of frame 18 was renumbered 17.
Prior to MARBE1, on OBH 17, flasher S/N 18063 was not working and was replaced by S/N F03010. Later in the lab, S/N 18063 worked OK.
Prior to MARBE1, on OBH 19, hydrophone S/N 1387 and leads 19BB were replaced with hydrophone S/N GF-13 and leads 33BM. Hydrophone S/N 1387 was needed for MISER #2.
Prior to MARBE1, on OBH 24, hydrophone leads were flipped so that the Burton connector went to the OBH and the Mecca connector went to the hydrophone.
Prior to MARBE1, on OBH 27, radio S/N E05003 put out a weak signal and was replaced by S/N G04001. Later in the lab, the pressure switch on S/N E05003 was found to be bad.
After MARBE1 recovery, on OBH 22, a leg that was cracked at the base and had a delrin footpad come loose was replaced.
Prior to MARBE5, on OBH 22, hydrophone S/N GF-6 and leads 21BB were replaced with hydrophone S/N GF-4 and newly constructed leads 40BM.
During MARBE5 deployment, on OBH 22, hydrophone leads 40BM were replaced by leads 14BB. The negative lead at the OBH did not stay securely seated.
Prior to MARBE6, on OBH 23, hydrophone S/N GF-7 and leads 39BM were replaced with hydrophone S/N GF-8 and leads 40BM.

Table A10-2

EW96-08
OBH ELECTRONICS CONFIGURATION

OBH	Preamp	Filter	LG GRA	HG GRA	P. S. I.*	Tattletale	Disk	Kato	Piggyback	Vectron Oscillaton	WET
16	16	5	8	2	5	145 Rev E TT6A	No S/N	No S/N	6	317Y1322 1218027	176
17	17	8	4	16	17	082 Rev C TT6A	26841631G MK1926FCV	76393	7	317Y1322 1218025	238
19	19	4	9	13	6	144 Rev E TT6A	26841638G MK1926FCV	81618 Rev B	4	318Y0467 1167150	174
20	20	15	5	26	4	166 Rev E TT6A	26841613G MK1926FCV	76394 Rev B	3	317Y1322 1218026	173
22	22	16	10	25	7	81 Rev E TT6A	36T13653P MK1926FCV	42 Rev A	2	317Y1322 1218024	229
23	23	2	14	24	12	138 Rev E TT6A	N/A	N/A	10	318Y0467 1167160	177
24	24	9	19	17	11	167 Rev E TT6A	24043482A MK2326FC	34 Rev A	11	318Y0467 1167159	204
25	25	17	11	12	8	165 Rev E TT6A	No S/N MK1926FCV	N/A	12	318Y0467 1167161	203
26	26	13	15	22	9	143 Rev E TT6A	26841627G MK1926FCV	117 Rev B	13	317Y1322 1218030	172
27	27	14	28	21	10	146 Rev E TT6A	24042781A MK2326FC	116 Rev A	5	317Y1322 1218028	175

*Power Supply Interface.
Pre-amp gain is +20dB.
Filter cutoff freq./type is 80Hz DEK 6 Pole LP with a gain of 1.
Low Gain GRA 1 (Channel 1) gain is 9.4 dB, attenuation is 7, type DEK.
High Gain GRA 0 (Channel 2) gain is 35.5 dB, attenuation is 7, type DEK.
Power Supply Interface Type is May 1991 with jumper positions W1 and W2 both set to 'A'.
Piggyback Board Type is KRP May 1991.
Program Version is 26 (24 July 1994).
Threshold value is 16300 A/D # (0-32000), 0.122 volts.
Sample rate is 200 samples/s.

Prior to MARBE3 deployment, the tattletale board S/N 166 and disk S/N 26841613G, model MK1926FCV, in OBH #20, were replaced by tattletale board S/N 168 and disk S/N 24042773A,
model MK2326FC (324Mb).

After MARBE3 recovery, the tattletale board S/N 144, model TT6A Rev. E, in OBH #19, was replaced by S/N 83, model TT6A Rev. C.

Prior to MARBE4 deployment, on OBH 24, the analog section was checked and cleaned. Checked the leads, preamp, connectors; reseated boards.

Prior to MARBE4 deployment, on OBH 26, the ribbon cable connecting the model 6 and analog section was shielded with aluminum foil and scotch tape to diminish the 1s. spikes

Table A10-3
OBH Repair Summary

Inst.	Deployment	Problem	Action	Result
19	MARBE3	1 Second Noise	Replace Model6	Fixed
20	MARBE2	PWR RST	Replaced Model6 & Disk	No Repeat
22	MARBE4	Spiky Data	Changed Phone & Leads	No Repeat
23	MARBE5	Small Signal & Noise	Changed Phone & Leads	No Repeat
24	MARBE4	Noisy Data	Cleaned Inst. Analog Section	No Repeat
26	MARBE4	1 Second Noise	Shielded Ribbon Cable	Half the Noise

In general, the OBHs performed exceptionally well. Given the shear number of deployments and the short turnaround time between deployments, the instruments have proven to be real workhorses. The OBHs had a 100% recovery rate and a data recovery rate of over 97%. This is performance to be truly proud of.

On instruments 19 & 26, we know the problem (1 second noise) to be caused by the Model6. This problem was easily reproduced on the test bench. OBH 26's Model6 was not replaced because we didn't have another Model6 to replace it with. The reason the Model6s went bad is not known. It may be a good idea to troubleshoot the Model6s in depth to find the failure mode.

OBH 20's failure is a mystery. We were not able to induce a similar failure on the bench. We believe the Model6 incurred a power reset. This seems like the only possible event that could cause the failure we saw.

On OBH 24, we found no problem. The instrument was deployed in the SOFAR channel and the high noise levels may be related to that.

Instruments 22 & 23 had what looked to be analog problems. We weren't able to reproduce the problems on the bench. However, we were able to duplicate the noise waveform signatures. On 22 you can reproduce the waveform by opening the hydrophone circuit. On 23 you can do it by shorting the + hydrophone side to frame. Although inconclusive, this demonstrates possible failure modes. The action and results tend to support the theory.

In terms of avoiding these problems on future legs, changing all the hydrophone connectors to Burton would be a good idea. The OBHs all have Burton connectors; if the hydrophones matched, there would be no need for hybrid cables, no splices. If all the connectors were identical it would be easier to detect subtle differences that may indicate a possible problem. All connectors being the same would work towards that end.

Appendix 11

ORB Configurations and Release Summary

TABLE A11-1
ORB COMPONENT CONFIGURATION

MISER S/N	Backplane	REFTEK Mem & Power	REFTEK Disk Power	CPU	Comm	A/D	Seagate Disk	Seascan Timebase	WHOI Power Bd.	WHOI Preamp	Benthos Ball	Edgetech Release	OAS Hydrophone
1	0543	0880	0428	1226	0416	0494	WX031748REP	075	1	2	59603	020612	GF-3 E-2PD
2	0544	0881	7600	1227	0419	0503	HB013728	086	2	4	59402	020613	1387 E-2SD
3	0562	0921	0521	1267	0457	0592	HB050527	085	3	3	59506	020785	1503 E-2SD
4	0571	0924	????	1264	0461	0552	HB073549	084	4	1	59633	020786	GF-14 E-2PD

Pre-amp gain is ????
Program Version is ????
Sample rate is 200 samples/s.

Prior to MARBE1, on ORB #2, hydrophone S/N 1502 was replaced by S/N 1387.

TABLE A11-2
ORB BURNWIRE
RELEASE STATISTICS

EXPT	MISER	# BURNS	1ST BURN	2ND BURN	3RD BURN	ADD'L BURNS	NO RESPONSE[1]	CONFIRMED RISE	BURN TIME[2]
Test	1	2	10/17 14:39:36	14:49:26			14:57	14:57	17:24
1	2	2	10/20 12:25:40	12:36			12:38:29	12:42-12:46	16:20-20:20
1	3	2	10/20 20:57:30	21:08			before 21:19	21:08	10:30
2	1	3+	10/24 01:34:25	01:36:11	01:45:39	01:57, 02:49 (disabled since ~01:55)		01:54	19:35
2	4	2	10/24 04:16	04:24			04:29	04:29	13
3	1	3	10/28 17:17	17:27[3], 17:35	17:45			17:51	34
3	2	2	10/28 12:04	12:13			12:19	12:19	15
3	3	3	10/28 23:28:17	23:38:35	00:09:10		00:13:13	00:13:13	44:56
5	1	2	11/11 16:59	17:09			17:16	17:16	17
5	2	2	11/11 07:34:32	07:43:46			07:46:54	07:46:54	12:22
5	3	2	11/11 03:59:59[3], 04:00:57	04:10:43			04:18	04:18	17:03
6	1	2	11/16 00:02:16	00:11:29				00:11:42	09:26
6	2	2	11/16 14:39	14:48			14:52	14:52	13
6	3	2	11/16 09:23:02	09:31:54				09:31:54	08:52

[1] Contact is temporarily lost with ORB when it inverts upon release.
[2] Burn time = Confirmed rise - 1st burn
[3] No confirmation pings.
One burn = 8:32
Two burns = 17:04
Three burns = 25:36

Appendix 12

ORB External Time Base Performance

Measuring the Seascan Time Base performance is complicated by a jitter in the time base readings. The @ character that is sent as the time string sync pulse on the SAIL O/C line of the Seascan Time Base is not hard wired to a hardware event. Therefore it has some jitter built in as a function of the software timing variations. To lessen the effect of this jitter several clock readings were taken each time the clock was set or debriefed and the high reading and the low reading were averaged together to get the "Average offset". The Average offset for the pre-deployment readings are subtracted from the Average reading of the post-recovery readings to get the "Change in seconds". The change of the SAIL clock as measured against the UTC clock is subtracted from the change of the time base to get the "time base drift in seconds". The "duration of drift in seconds" is the average number of seconds between the time base readings at deployment to the time base readings at recovery. The "drift rate" is computed by dividing the time base drift by the duration of drift. The time base drifts ranged from 2 parts in 10 **11 to 34 parts in 10**9 which put them within their specifications.

To test a procedure to get rid of the jitter in the time base readings, the one second pulse of the time base, which is hardwired to a hardware event, was brought out of the glass ball on ORB3 and tied to the @ generator of the SAIL/RS232 interface box. Three readings were taken in the normal manner and yielded a jitter of 254 us. several readings were taken using the one second pulse. These readings had less than 1 us of jitter. However, it was difficult to correlate the second of the time base readings with the second of the SAIL clock. A procedure will have to be developed to eliminate any one second ambiguity between the time base and the SAIL clock.

```
293:16:40:11@
 :
293:16:40:15@
 :
293:16:40:18@
 : 0293 16:40:17.999933     These manual readings give 254 us of jitter
   0293 16:40:15.000158
   0293 16:40:10.999904

:@@@@@@@@
   0293 16:41:44.999825
   0293 16:41:43.999825     These readings synched to the one second pulse are within a
1 us range
   0293 16:41:42.999826
   0293 16:41:41.999826
```

MARBE1							
		Time Base offset from SAIL pre-deployment	Time Base offset from SAIL post-recovery	Change seconds	Time Base Drift seconds	Duration of drift seconds	Drift Rate
ORB3	TB High	291 23:17:05.011894	295 03:01:20.021358				
TB85	TB Low	291 23:16:58.011856	295 03:01:23.021133				
	Average offset	.011875	.021246	.009371			
					.009304	272655	34X10-9
	jitter us	38	225				
	SAIL UTC offset	.000049	.000116	.000067			
ORB2	TB High	292 12:49:54.001476	294 15:03:33.001003				
TB86	TB Low	292 12:49:50.001215	294 15:03:41.000681				
	Average offset	.001346	.000842	-.000504			
					-.000548	180827	3X10-9
	jitter us	261	322				
	SAIL UTC offset	.000061	.000104	.000044			

MARBE2							
		Time Base offset from SAIL pre-deployment	Time Base offset from SAIL post-recovery	Change seconds	Clock Drift seconds	Duration of drift seconds	Drift Rate
ORB1	TB High	295 06:10:11.000314	298 03:41:45.998849				
TB75	TB Low	295 06:10:04.999934	298 03:41:48.998616				
	Average offset	.000124	.998732	-.001392			
					-.001454	250304	6X10-9
	jitter us	380	233				
	SAIL UTC offset	.000118	.000180	.000062			
ORB4	TB High	295 15:53:15.000194	298 06:21:25.999895				
TB84	TB Low	295 15:53:17.999971	298 06:21:28.999661				
	Average offset	.000083	.999778	-.000305			
					-.000362	225851	2X10-9
	jitter us	223	234				
	SAIL UTC offset	.000126	.000183	.000057			

MARBE3							
		Time Base offset from SAIL pre-deployment	Time Base offset from SAIL post-recovery	Change second s	Clock Drift seconds	Duratio n of drift second s	Drift Rate
ORB1	TB High	298 18:00:43.998840	302 18:59:33.99902 4				
TB75	TB Low	298 18:00:37.998457	302 18:59:36.99879 1				
	Averag e offset	.998816	.998908	.00009 2			
					.000008	349136	2.3X10- 11
	jitter us	383	233				
	SAIL UTC offset	.000193	.000277	.00008 4			
ORB2	TB High	297 13:49:19.000377	302 13:22:16.99797 7				
TB86	TB Low	297 13:49:15.000114	302 13:22:12.99772 4				
	Averag e offset	.000246	.997850	- .00239 6			
					- .002503	430374	6X10-9
	jitter us	263	253				
	SAIL UTC offset	.000169	.000273	.00010 7			
ORB3	TB High	297 17:53:14.000043	303 01:28:04.01400 6				
TB85	TB Low	297 17:53:16.999822	303 01:28:01.01381 9				
	Averag e offset	.999932	..013912	.01398 0			
					.013869	459287	30X10-9
	jitter us	221	187				
	SAIL UTC offset	.000172	.000283	.00011 1			

ORB4	TB High	299 01:33:33.999367	NA				
TB84	TB Low	299 01:33:36.999144	NA				
	Average offset	.999256	NA				
	jitter us	223	NA				
	SAIL UTC offset	.000200	NA				

MARBE5							
		Time Base offset from SAIL pre-deployment	Time Base offset from SAIL post-recovery	Change seconds	Clock Drift seconds	Duration of drift seconds	Drift Rate
ORB1	TB High	311 16:56:53.992806	316 22:08:14.993433				
TB75	TB Low	311 16:56:46.992551	316 22:08:11.993245				
	Average offset	.992678	.993339	.000661			
					.000552	450694	1X10-9
	jitter us	255	188				
	SAIL UTC offset	.000463	.000572	.000109			
ORB2	TB High	311 12:50:39.000377	316 09:37:12.997723				
TB86	TB Low	311 12:50:42.000158	316 09:37:09.997532				
	Average offset	.000268	.997628	-.002640			
					-.002742	420398	7X10-9
	jitter us	219	.000191				
	SAIL UTC offset	.000460	.000563	.000102			
ORB3	TB High	311 20:49:13.000113	316 05:37:01.012186				
TB85	TB Low	311 20:49:15.999894	316 05:37:57.011938				
	Average offset	.000004	.012062	.012058			
					.011966	377264	32X10-9
	jitter us	219	248				
	SAIL UTC offset	.000466	.000558	.000092			

MARBE6							
		Time Base offset from SAIL pre-deployment	Time Base offset from SAIL post-recovery	Change seconds	Clock Drift seconds	Duration of drift seconds	Drift Rate
ORB1	TB High	316 23:33:27.997064	321 15:59:17.992518				
TB75	TB Low	316 23:33:23.996802	321 15:59:20.992292				
	Average offset	.996933	.992405	-.004528			
					-.004629	404753	11X10-9
	jitter us	262	226				
	SAIL UTC offset	.000574	.000675	.000101			
ORB2	TB High	316 10:34:52.012560	321 10:44:09.011689				
TB86	TB Low	316 10:34:48.012302	321 10:44:06.011503				
	Average offset	.012431	..011596	-.000835			
					-.000943	432561	2X10-9
	jitter us	258	186				
	SAIL UTC offset	.000563	.000671	.000108			
ORB3	TB High	317 07:21:46.993519	321 01:25:29.994444				
TB85	TB Low	317 07:21:42.993265	321 01:25:25.994198				
	Average offset	.993392	..994321	.000929			
					.000847	324223	3X10-9
	jitter us	254	246				
	SAIL UTC offset	.000580	.000662	.000082			

Appendix 13

ORB Mechanical Performance and Proposed Modifications

Acoustic Issues

In general, the ORB instrument responds well to commands and depth interrogations as long as the instrument is in the transducer-up position, i.e. its anchored configuration. However, when the anchor is released, and the instrument inverts, contact is usually lost, presumably because the glass sphere shields the transducer from commands from the ship. This leads to uncertainty about the time of release. It is not always possible to equate loss of contact with the release of an instrument from the bottom, particularly when the ship has drifted off station during the time required for the burn wire to dissolve, and communication has become intermittent because of the horizontal separation. Additionally, the ship's drift from station combined with the need to send multiple release commands can introduce doubt regarding release time; in noisy conditions, the acknowledgment pings cannot always be heard with certainty. This can lead to sending multiple commands, with doubt as to which one started the burn wire dissolution.

It is assumed that the difficulties in communicating with the instrument would be alleviated if the transducer always pointed upward. But the inversion upon release is used to actuate recovery aid flashers, and more importantly, the downward pointing transducer allows ranging to the instrument when it is on the surface, an important location method should it not be sighted upon surfacing.

We feel that it's likely that the difficulty in communication is a result of the ORB not hearing the interrogations or commands from the ship while inverted. Tests should be done to determine whether transmission from the ORB could be heard on the ship with the transducer pointed down. Similar downward-pointing transducers on bottom finding pingers are easily received at the surface. A possible test method would involve removal of the shielding from one of the flashers. It is known that radiation from these flashers causes pinging of the ORB transducer if the flashers aren't shielded. One deployment in deep water with good conditions for visual location after release would indicate whether transmission from the downward-facing transducer could be heard from the surface. If so, a method for producing a series of pings upon inversion that would not interfere with later ranging on the surface could be devised. One possibility would be to induce pinging by radiation from an unshielded source on a timer, causing the transducer to transmit for, say, thirty seconds following release and consequent activation by tip-over switch.

A second transponder/release issue mentioned above is the necessity for multiple release commands when the instrument is deployed in deep, cold water, as is usually the case. The maximum burn time selectable on the release board is about 8.5 minutes, and the time required for release seems to average about 15 minutes. Since release batteries are replaced before each ORB is deployed, it would seem to be reasonable to change the circuitry so that once activated the burn wire circuit would stay active until the batteries were exhausted. In this way, release-time (and consequently surface-time) probably could be estimated fairly accurately. For check-out procedures, some sort of reset control would be required to turn off the burn wire before deployment. This modification in the release circuit would also eliminate the long time (about 17 minutes per instrument) currently spent checking its voltage and timer. The following questions are applicable. (1) Do commands stack? i.e. if one sends two release commands does the burn wire stay active for twice the time? Probably not, but this can be checked easily. (2) Does sending a disable command turn the release circuit off? Again, probably not, but this too should be checked.

time? Probably not, but this can be checked easily. (2) Does sending a disable command turn the release circuit off? Again, probably not, but this too should be checked.

Mechanical Issues

Mechanical issues involving the ORB instrument system fall into three areas: (i) the components of the instrument itself; (ii) methods of handling and storing the instruments in the laboratory; and (iii) the deployment system.

Instrument Components

In general, the mechanical configuration of the instrument seems to be serviceable and robust enough for use at sea. No failures of the spherical glass housing, protective hard hat, through-glass penetrators, or associated hardware were observed during the cruise. There exist, however, several areas where improvements should be made before we move on from these prototype instruments toward what might be described as production units.

The external cable assembly which provides connection to the hydrophone and burn wire requires further adjustment. The exit of the cables between the hardhat halves presents the possibility of damage if the instrument is set down with the wires pinched between the deck and the edge of the hardhat. And lengths of individual cables in the assembly are too long to be properly routed from their exit through the hardhat to the hydrophone.

The cables which power the burn wire release are presently run along the bail where they are vulnerable, especially during recovery operations. The burn wire return runs the entire length of the bail before connecting to the permanent cable assembly. Since this wire is replaced after each deployment, recovery damage would not endanger later releases. But it might be possible to attach the return wire terminal to the bail at its lower end, and eliminate this long wire entirely. Tests should be performed to determine the effectiveness of this connection. During this cruise, the connection between the burn wire return and the bail was potted using RTV silicon rubber sealant. We should determine if this potting is effective or necessary.

The burn wire power lead is relatively short, so the permanent cable must be run to it along the bail. Damage to this permanent wire during recovery operations could jeopardize subsequent releases if it went unrepaired. Two solutions to this possible problem might be: (i) change the bail design from the present solid rod stock to tubular stock, and route the burn wire power lead inside the bail; (ii) lengthen the power lead that is integral with the burn wire, and shorten the permanent cable so that the wire routed along the bail will be changed before each deployment.

The internal wiring of the instrument also needs to be standardized for the "production" instruments. Wires should be bundled into groups that work well together (i.e. do not interfere with each other), and attached to the chassis in identical ways, so that cabling is neat and interchangeable.

Battery pack construction should be reassessed based on changes made to battery utilization just before and during this expedition.

The protective cage for the hydrophone is quite hard to install. It could be moved approximately one quarter of an inch further from the center of the hard hat to facilitate mounting and removal.

A mount for the recovery aid flag should be designed and added to the instruments. Presently the flag is taped to the bail, adding to the difficulty of handling and storing the bail and the complete instrument.

Instrument Storage and Preparation

Although light in weight and small in size relative to other instruments, ORBs present a handling problem, because they are brought into the lab. in their entirety. They are quite easily carried by two people, utilizing the integral handles, but are hard to store, both in and out of their hardhats, and the handles molded into the hardhats have sharp corners. Contoured handles will be provided on future instruments, and fitted to the present ones.

Storage for complete instruments could probably best be provided by a rack system in which the ORBs were suspended by the small bail at the hydrophone end of the hardhat. Four instruments could be accommodated in a space about two feet by four feet by five feet high.

Storing the instruments once removed from their hardhats presents a more complex problem. The hemisphere containing the electronics has the acoustic transducer located at its pole, and four connectors evenly spaced around a latitudinal circle 60 degrees from the pole. Assembly and disassembly of the glass instrument housing is facilitated if the sphere is free to rotate and it is essential that twenty degrees of latitude centered on the equator is unobstructed. The small, rotating, cylinder we have used to hold the lower hemisphere during this cruise does not inspire confidence. It is secured to the glass by evacuation of the internal volume of the cylinder. A slow leak and a hard roll could result in a broken instrument housing.

A new storage/handling system should be designed for the glass instrument housings. This system should incorporate the following features:

- The lower hemisphere should be recessed into a horizontal surface to an extent that will prevent it's falling out, even in high sea states.
- Sufficient clearance should be provided to prevent damage to the transducer or connectors, and provide access for connecting test cables.
- The system should incorporate a fixture to facilitate lifting the sphere/hemispheres without damaging the connectors or transducer.
- Access to the vacuum port should be provided.
- The recessed base should be free to rotate, giving access to th entire equator of the sphere.

Instrument Deployment

The ORB is light and easily deployed. During this cruise, they were deployed by utilizing the same small, portable winch used for the standard OBHs. They were lifted by this winch via a quick-release hook. A short slip line was added between the hook and instrument bail in order to provide clearance between the relatively heavy hook body and the OAS hydrophone and transducer. Once the ORB was over the side, its anchor was lowered with a slip line until its weight bore on the instrument. The assembly was then lowered to the water and released. ALVIN dive weights were used as anchors on this expedition. Less expensive and more easily handled cast anchors should be employed in the future.

A time is envisioned when large numbers of these instruments will be deployed from a variety of vessels. It will be advantageous to employ a system which is independent of ship's equipment, and which will allow instrument deployment while the ship is underway at slow speed, say three to four knots.

We propose to design and build a system for carrying out these multiple deployments. This system will allow the instruments to slide down a chute or a rail extending aft and downward from the ship's stern. It will be possible to adjust the angle of this gear so that it will cause the ORBs to slide astern at near ship speed, and therefore have very low velocity relative to the water. Once the instrument is free astern, its anchor will be released. If a fairly long pennant is used on the anchor, say 5 meters, little shock will be transferred to the instrument as the anchor sinks and comes to bear on it.

If we are to work toward the goal of being able to deploy large numbers of ORBs, the check-out procedure will need to be simplified. The new procedure will have to be a compromise between detailed assurance that all the instrument functions are operating properly, and the ability to launch twenty to fifty instruments in a timely fashion. The check-out process presently in place is simply too time consuming. An extreme example is the release circuit, which is tested twice each time an instrument is launched consuming about 18 minutes per instrument. That would be six hours for twenty instruments, a major percentage of the total time allotted to deploy a twenty instrument array! At some point we need to develop confidence that this and other instrument sub-systems will function, and adopt a simplified preparation procedure centered on programming and clock setting.

Finally, we should not lose sight of the longer term goal of being able to conduct multiple, short duration, active source experiments without opening the instrument housings, although there are major data transcription and power issues to deal with in order to achieve it.

Appendix 14

MCS Streamer Configuration for EW 96-08

EW9608----Final streamer configuration as deployed Nov 2, 1996.

Section Number	Section Type	Sect. s/n	Can s/n	Remarks
--	50-m Tailrope	????		
01	100m DSS240 Active	1456	798	Bird 1(C)
02	100m DSS240 Active	1486	1029	
03	" " "	9409	061	Bird 2
04	" " "	9456	3237	
05	" " "	1348	3255	Bird 3
06	" " "	1523	L1150	
07	" " "	1246	1141	Bird 4
08	" " "	1554	3046	
09	" " "	9569	1498	Bird 5
10	" " "	1593	1254	
11	" " "	1105	803	Bird 6(C)
12	" " "	1460	1449	
13	" " "	9466	3102	Bird 7
14	" " "	1416	1239	
15	" " "	9453	1046	Bird 8
16	" " "	L9573	3109	
17	" " "	9450	1248	Bird 9
18	" " "	9140	158	
19	" " "	9318	3047	Bird 10
20	" " "	9451	3228	
21	" " "	L9571	L963	Bird 11(C)
22	" " "	9529	1345	
23	" " "	9564	3302	Bird 12
24	" " "	9109	3139	
25	" " "	L9568	471	
26	" " "	L9572	3202	Bird 13
27	" " "	L9570	1429A	
28	" " "	L9574	1521A	
29	" " "	9575	1352	
	Power Adapter(3 m)	PWR1		Bird 14
30	100m CANTO Active	2021	8450	
31	" " "	2015	8204	
32	" " "	2053	8223	Bird 15
33	" " "	2055	8217	
34	" " "	2012	8240	
35	" " "	2028	8220	Bird 16(C)
36	" " "	2022	8212	
37	" " "	2041	8216	Bird 17
38	" " "	2005	8209	
39	" " "	2029	8232	
40	" " "	2009	8404	Bird 18
41	100m CANTO Active	6205		
	Tow leader(50m past stern)			
42	Impedance Converter	8318		

EW9608.mcs--Streamer and Gun configurations as used during Ew9608. EW9608 was an OBH shoot with a MCS add-on in the middle. A different gun configuration was used for the MCS portion.

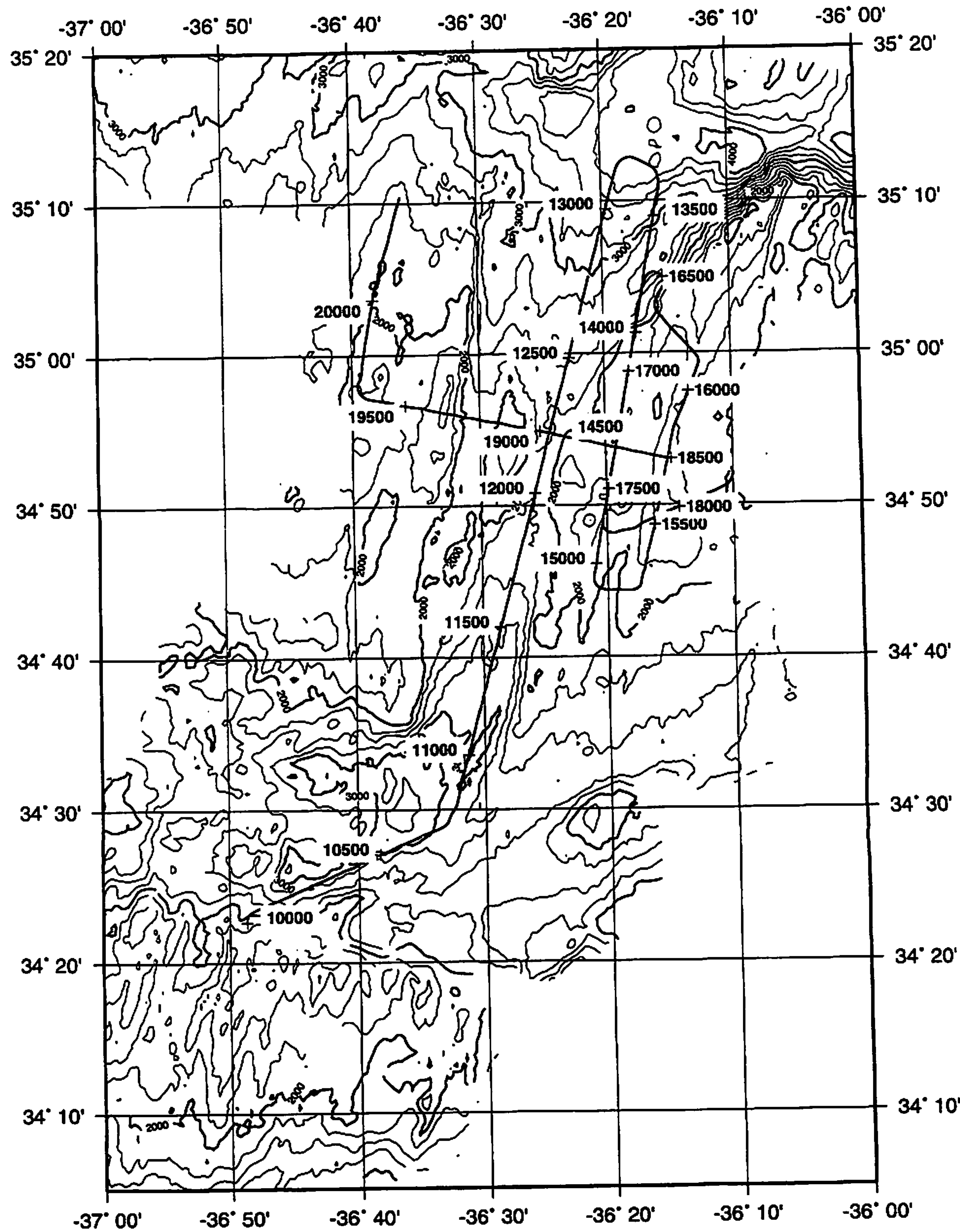
Offsets for Gun Array and Streamer as used on EW9608.

```
     x     Mast(GPS Antennae)
     |
     |
     |
     |
  50 Meters
     |
     |
     |
     |
     |
     x     Stern
     |
     |
     |
  40 Meters
     |
     |
     |
     |
     x     Center of Gun Array
     |
     |
  120 Meters
     |
     |
     x     Center of 1st Seismic Channel.
```

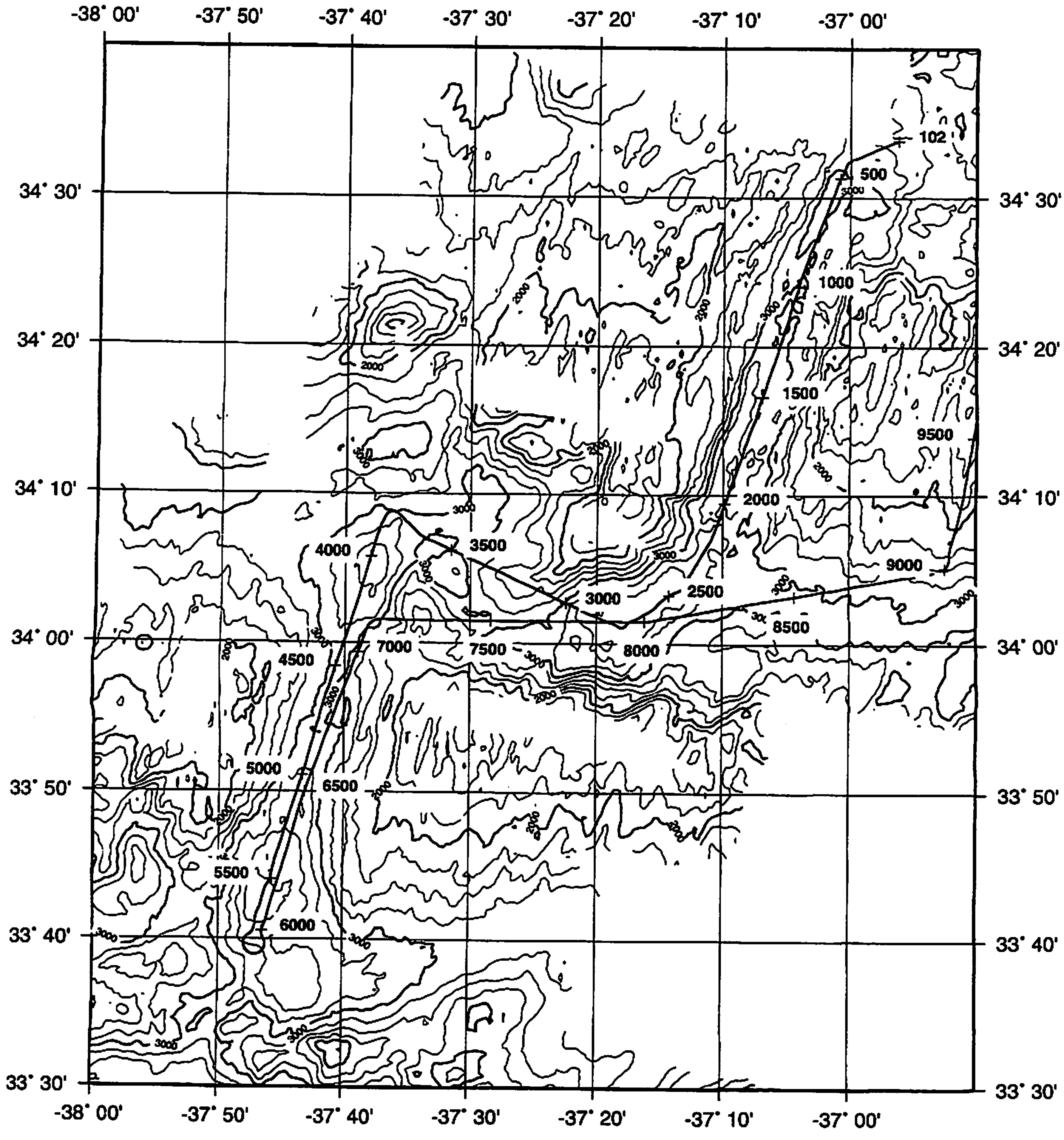
Appendix 15

MCS Line Log and Shotpoint Maps

BULLSEYE Cruise, Shot Points During MCS, Northern Area



BULLSEYE Cruise, Shot Points During MCS, Southern Area



J.D.	start/ end	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Depth (m)	Comments
307	start	07:12			1	413	1		11/2/1996 First shot
	end	07:35	34°31.3070	37°0.8066	1	500	88		
	start	07:36			2	501	89		
	end	07:45			2	535			Passing waypoint 2.1
	end	07:59	34°30.0003	37°1.3883	2	588	176		
	start	07:59			3	589	177		
	end	08:23	34°28.7132	37°1.9886	3	676	264		
	start	08:23			4	677	265	2942	
	end	08:46	34°27.4906	37°2.6192	4	764	352		
	start	08:46			5	765	353	2962	
	end	09:09	34°26.1841	37°3.2125	5	852	440		
	start	09:09			6	853	441	2984	
		09:30				927			Passing waypoint 2.2
	end	09:33	34°24.8717	37°3.7680	6	940	528	3046	
	start	09:33			7	941	529		
	end	09:56	34°23.5836	37°4.2436	7	1028	616	3077	
	start	09:56			8	1029	617		
	end	10:20	34°22.116	37°4.7890	8	1116	704		
	start	10:20			9	1117	705	3067	
	start	11:07			10	1205	793		
	end	11:07			10	1292	880		
	start	11:07			11	1293	881		
	end	11:30			11	1380	968	3050	
	start	11:30			12	1381	969		
	end	11:53			12	1468	1056	3059	
	start	11:53			13	1469	1057		
	end	12:17			13	1556	1144	3158	
	start	12:17			14	1557	1145		
	end	12:41			14	1645	1232	3230	
	start	12:41			15	1646	1233		
	end	13:05			15	1733	1320	3286	
	start	13:05			16	1734	1321		
	end	13:28			16	1821	1408	3302	
	start	13:28			17	1822	1409		
	end	13:52			17	1910	1496	3414	
	start	13:52			18	1911	1496		
	end	14:10			18	1998	1584	3255	
	start	14:10			19	1999	1585		
	end	14:40			19	2086	1672	3322	
	start	14:40			20	2087	1673		
	end	15:04			20	2174	1760	3154	
	start	15:04			21	2175	1761		
	end	15:27			21	2262	1848	3362	
	start	15:27			22	2263	1849		
	end	15:51			22	2350	1936	3453	
	start	15:51			23	2351	1937		
	end	16:14			23	2438	2024	3515	

J.D.	start/ end	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Depth (m)	Comments
	start	16:14			24	2439	2025		
	end	16:37			24	2526	2112	3433	
	start	16:37			25	2527	2113		
	end	17:01			25	2614	2200	3536	
	start	17:01			26	2165	2201		
	end	17:24			26	2702	2288	3541	
	start	17:24			27	2703	2289		
	end	17:48			27	2790	2376	3508	
	start	17:48			28	2791	2377		
	end	18:10			28	2464	2878	3575	
	start	18:10			29	2465	2879		
	end	18:33			29	2552	2966		
	start	18:33			30	2553	2967		
	end	18:57			30	2640	3054		
	start	18:57			31	2641	3055		
	end	19:20			31	2728	3142		
	start	19:20			32	2729	3143	2525	
	end	19:44			32	3230	2816		
	start	19:44			33	3231	2817		
	end	20:07			33	3318	2904		
	start	20:07			34	3319	2905		
	end	20:31			34	3406	2992		
	start	20:31			35	3407	2993		
	end	20:54			35	3494	3080		
	start	20:54			36	3495	3081		
	end	21:18			36	3582	3168		
	start	21:18			37	3583	3169		
	end	21:41			37	3671	3257		
	start	21:41			38	3672	3258		
	end	22:04			38	3759	3344		
	start	22:04			39	3760	3345		
	end	22:32			39	3847	3432		
	start	22:32			40	3848	3433		
	end	22:51	34° 6.7387	37°37.649	40	3935	3520	3576	
	start	22:52			41	3936	3521		
		23:04			41	3984	3569	3573	Passing waypoint 2.8
	end	23:15	34° 5.4400	37°38.115	41	4023	3608	3588	
	start	23:15			42	4024	3609		
	end	23:38	34° 4.1415	37°38.574	42	4111	3696		
	start	23:39			43	4112	3697	3488	SP 4160: "File may be bad"
308	end	00:02			43	4199	3784		11/3/96
	start	00:02			44	4200	3785	3260	
	end	00:25			44	4287	3872		
	start	00:25			45	4289	3874	3168	
		00:30			45	4303			Pasing waypoint 2.9
	end	00:49	34° 0.243	37°39.993	45	4375	3960		
	start	00:49			46	4376	3961	3158	
	end	01:12	33° 58.904	37°40.547	46	4463	4048		
	start	01:12			47	4464	4049	3155	

J.D.	start/ end	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Depth (m)	Comments
	end	01:36	33°57.596	37°41.046	47	4551	4136		
	start	01:36			48	4552	4137	3037	
	end	02:00	33°56.237	37°41.550	48	4639	4224	3026	
	start	02:00			49	4640	4225	3025	
		02:03			49	4651	4236		Passing waypoint 2.10
	end	02:23	33°55.093	37°41.996	49	4727	4312		
	start	02:23			50	4728	4313	3061	
	end	02:46	33° 53.826	37°42.408	50	4815	4400		
	start	02:47			51	4816	4401	3161	
	end	03:10	33° 52.521	37°42.840	51	4903	4488		
	start	03:10			52	4904	4489	3191	
		03:23			52	4958	4543		Shot not recorded.
		03:26	33° 51.610	37° 43.157	52	4965	4550		Passing waypoint 2.11
	end	03:34	33° 51.222	37° 43.296	52	4992	4576		
	start	03:34			53	4993	4577	3314	
	end	03:57	33° 49.972	37° 43.750	53	5080	4664		
	start	03:57			54	5081	4665	3449	
	end	04:21	33° 48.747	37° 44.251	54	5168	4752		
	start	04:21			55	5169	4753	3486	
	end	04:44	33° 47.502	37° 44.702	55	5256	4840		
	start	04:44			56	5257	4841	3578	
		04:59	33° 46.711	37° 44.993	56	5313	4897		Passing waypoint 2.12
	end	05:08	33° 46.285	37° 45.123	56	5344	4928		
	start	05:08			57	5345	4929	3654	
	end	05:31	33° 45.041	37° 45.575	57	5432	5016		
	start	05:31			58	5433	5017	3706	
	end	05:54	33° 43.761	37° 45.952	58	5520	5104		
	start	05:54			59	5521	5105	3830	
	end	06:17	33° 42.535	37° 46.519	59	5608	5192	3830	
	start	06:18			60	5609	5193		
		06:25	33° 42.130	37° 46.669	60	5634	5194		Passing waypoint 2.13
	end	06:41	33° 41.178	37° 47.016	60	5696	5280	3649	
	start	06:41			61	5697	5281		
	end	07:04	33° 40.001	37° 47.838	61	5784	5368	3448	
	start	07:05			62	5785	5369		
	end	07:28	33° 38.9312	37° 47.1148	62	5872	5456	3433	
	start	07:28			63	5873	5457		
	end	07:51	33° 39.8808	37° 46.2303	63	5960	5544	3492	
	start	07:52			64	5961	5545		
	end	08:15	33° 41.4246	37° 46.0895	64	6048	5632	3627	
	start	08:15			65	6049	5633		
	end	08:38	33° 43.1059	37° 45.5523	65	6136	5720		
	start	08:38			66	6137	5721		
	end	08:45			66	6163	5747	3766	Ejected prematurely, shot
	start	08:46			67	6165	5749		shots 6165-6183 navtape
	end	09:09			67	6251	5835	3664	change lost nav for
	start	09:09			68	6252	5836		
		09:20				6291			Passing WP 2.16
	end	09:32	33° 46.9142	37° 44.2390	68	6339	5923	3669	

J.D.	*start/ end*	*Time (Z)*	*Latitude (Start/End)*	*Longitude (Start/End)*	*Tape #*	*Shot #*	*File #*	*Depth (m)*	*Comments*
	start	09:33			69	6340	5924		
	end	09:56	33°48.94	37° 43.55	69	6427	6011	3436	
	start	09:56			70	6428	6012		
	end	10:20	33° 50.6389	37° 42.8856	70	6515	6099	3379	
	start	10:20			71	6516	6100		
	end	10:43	33° 52.3710	37° 42.0993	71	6603	6187	3379	
	start	10:43			72	6604	6188		
	end	11:07	33° 54.103	37° 41.313	72	6691	6275	3120	
	start	11:07			73	6692	6276		
	end	11:30	33° 55.549	37° 40.639	73	6779	6363	2933	
	start	11:30			74	6780	6364		
		11:41				6820	6404		Passing WP 2.18
	end	11:54	33° 57.047	37° 39.978	74	6867	6451	3024	
	start	11:54			75	6868	6452		
	end	12:17	33° 58.538	37° 39.319	75	6955	6539	2737	
	start	12:17			76	6956	6540		
	end	12:40	34° 00.1672	37° 38.5973	76	7043	6627	2815	
	start	12:40			77	7044	6628		
		13:00				7166	6700		Gun #9 brought in
	end	13:04	34° 01.5614	37° 37.4053	77	7131	6715	2885	
	start	13:04			78	7132	6716		
	end	13:27	34° 01.5186	37° 35.2750	78	7219	6803	2466	
	start	13:27			79	7220	6804		
	end	13:51	34° 01.516	37° 32.996	79	7307	6891	2317	
	start	13:51			80	7308	6892		
	end	14:03	34° 01.25	37° 30.77	80	7395	6979	2492	
	start	14:03			81	7396	6980		
	end	14:37	34° 01.49	37° 28.69	81	7483	7067		14:21 Gun #9 firing
	start	14:38			82	7484	7068		
	end	15:01	34° 01.50	37° 26.47	82	7571	7155	3157	
	start	15:01			83	7572	7156		15:17 Gun#12 not firing
	end	15:24	34° 01.515	37° 24.099	83	7659	7243	3084	
	start	15:25			84	7660	7244		
	end	15:48	34° 01.503	37° 22.009	84	7747	7331	3307	
	start	15:48			85	7748	7332		
	end	16:11	34° 01.484	37° 19.930	85	7835	7419	3546	16:06 Gun #12 firing
	start	16:12			86	7836	7420		
	end	16:35	34° 01.50	37° 18.35	86	7923	7507	3502	
	start	16:35			87	7924	7508		
	end	16:58	34° 01.526	37° 15.758	87	8011	7595	3269	
	start	16:58			88	8012	7576		
	end	17:22	34° 01.859	37° 13.554	88	8099	7683	2995	
	start	17:22			89	8100	7684		
	end	17:45	34 02.145	37 11.608	89	8187	7771	2923	
	start	17:45			90	8188	7772		
	end	18:09	34 02469	37 09.613	90	8275	7859	2821	
	start	18:09			91	8276	7860		
		18:16							Error message
	end	18:32	34 02.7702	37 07.5224	91	8363	7947	2947	

Appendix 15 EW9608 MCS Line Log

J.D.	start/ end	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Depth (m)	Comments
	start	18:32			92	8364	7948		
	end	18:56	34° 3.0458	37° 5.5018	92	8451	8035	3066	
	start	18:56			93	8452	8036		
	end	19:19	34° 3.347	37° 3.312	93	8539	8123	2998	
	start	19:19			94	8540	8124		
	end	19:43	34° 3.6302	37° 1.3793	94	8627	8211	3017	
	start	19:43			95	8628	8212		
	end	20:06	34° 3.9711	36° 59.2748	95	8715	8299	3003	
	start	20:06			96	8716	8300		
	end	20:30	34° 4.361	36° 56.413	96	8803	8387	2944	
	start	20:30			97	8804	8388		
	end	20:53	34° 4.542	36° 55.067	97	8891	8475	2851	
	start	20:53			98	8892	8476		
	end	21:25	34° 5.2877	36° 52.292	98	9009	8563	2643	
	start	21:25			99	9010	8564		
	end	21:48	34° 6.763	36° 51.959	99	9097	8651	2279	
	start	21:48			100	9098	8652		
	end	22:11	34° 8.344	36° 51.4205	100	9185	8739	2136	
	start	22:12			101	9186	8740		
		22:33				9266	8820		Passing Waypoint 2.22
	end	22:35	34° 9.858	36° 51.0126	101	9273	8827	1825	
	start	22:35			102	9274	8828		
	end	22:58	34° 11.3990	36° 50.687	102	9361	8915	1625	
	start	22:59			103	9362	8916		
	end	23:22	34° 12.979	36° 50.4148	103	9449	9003	1557	
	start	23:22			104	9453			Passing Waypoint 2.23
		23:22			104	9450	9114		
		23:34				9494			Gun #12 operational
	end	23:45	34° 14.5315	36° 50.1825	104	9537	9091	1499	
	start	23:45			105	9538	9092		
	end	00:09			105	9625	9179	1433	
	start	00:09			106	9626	9180		
		00:24				9679			Passing Waypoint 2.24
		00:30				9701			Shot clock time error:
						9702	9255		possible missed shots
	end	00:32	34° 17.642	36° 49.6421	106	9714	9267	1401	
	start	00:33			107	9715	9268		
	end	00:56	34° 19.1705	36° 49.3435	107	9802	9355	1352	
	start	00:56			108	9803	9356		
	end	01:19	34° 20.7374	36° 49.0308	108	9890	9443	1580	
	start	01:20			109	9891	9444		
		01:38				9960			Passing Waypoint 2.25
	end	01:43	34°22.2621	36° 48.7138	109	9978	9531	1640	
	start	01:43			110	9979	9532		
		01:55			110	10022	9575		Leak on gun #3. Pulling it in.
	end	02:07	34° 23.4886	36° 47.8316	110	10066	9619		
	start	02:07			111	10067	9620	1568	
	end	02:30	34° 24.1871	36° 45.8797	111	10154	9707		
	start	02:31			112	10155	9708	2061	

J.D.	*start/ end*	*Time (Z)*	*Latitude (Start/End)*	*Longitude (Start/End)*	*Tape #*	*Shot #*	*File #*	*Depth (m)*	*Comments*
	end	02:54	34° 24.9423	36° 43.9371	112	10242	9795		
	start	02:54			113	10243	9796	2457	
		02:59			113				Gun #3 going back in water.
		02:59			113				Pulling in gun #5
		03:14			113				Gun #5 going back in water.
	end	03:17	34° 25.6599	36° 42.0284	113	10330	9883		
	start	03:17			114	10331	9884	2503	
		03:18			114				Pull in gun #9 to check it.
		03:29			114				Gun #9 going back in water.
	end	03:41	34° 26.3658	36° 40.1147	114	10418	9971		
	start	03:41			115	10419	9972	2440	
	end	04:04	34° 27.1093	36° 38.1694	115	10506	59		
	start	04:04			116	10507	60	2476	
		04:27			116	10590	143		Shot not recorded; acq. error.
	end	04:28	34° 27.8344	36° 36.2475	116	10595	147		
	start	04:28			117	10596	148	2609	
	end	04:51	34° 28.5196	36° 34.3227	117	10683	235		
	start	04:52			118	10684	236	2741	
	end	05:15	34° 29.5845	36° 32.8067	118	10771	323		
	start	05:15			119	10772	324	2831	
	end	05:38	34° 31.0776	36° 32.1261	119	10859	411		
	start	05:38			120	10860	412	2910	
	end	06:02	34° 32.7324	36° 31.5742	120	10947	499		
	start	06:02			121	10946	500	3004	
	end	06:25	34° 34.2199	36° 31.1033	121	11035	587		
	start	06:25			122	11036	588		
	end	06:49	34° 35.7256	36° 30.6282	122	11123	675	2964	
	start	06:49			123	11124	676		
	end	07:12	34° 37.1754	36° 30.1395	123	11211	763	2889	
	start	07:12			124	11212	764		
	end	07:36	34° 38.6375	36° 29.6941	124	11299	851	2819	
	start	07:36			125	11300	852		
	end	07:59	34° 40.1283	36° 29.2209	125	11387	939	2784	
	start	07:59			126	11388	940		
	end	08:23	34° 41.5893	36° 28.7660	126	11475	1027	2752	
	start	08:23			127	11476	1028		
	end	08:46	34° 43.0879	36° 28.2306	127	11563	1115	2818	
	start	08:46			128	11564	1116		
	end	09:09	34° 44.6390	36°27.7627	128	11651	1203	2702	
	start	09:10			129	11652	1204		
	end	09:33	34° 46.1765	36° 27.2513	129	11739	1291	2437	
	start	09:33			130	11740	1292		
	end	09:56	34° 47.7344	36° 26.7420	130	11827	1379	2363	
	start	09:56			131	11828	1382		
		10:15				11899	1451		Passing WP 1.7
	end	10:20	34° 49.296	36° 26.161	131	11915	1467	2270	
	start	10:20			132	11916	1468		
	end	10:33			132	11964	1516		stopped writing early
	start	10:33			133	11965	1517		

Appendix 15 EW9608 MCS Line Log

J.D.	start/ end	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Depth (m)	Comments
	end	10:56	34° 51.76	36° 25.44	133	12052	1604	2178	
	start	10:56			134	12053	1605		
	end	11:20	34° 53.25	36° 24.95	134	12140	1692	2179	
	start	11:20			135	12141	1693		
	end	11:43	34° 54.92	36° 24.42	135	12228	1780	2232	
	start	11:43			136	12229	1781		
	end	12:07	34° 56.42	36° 23.96	136	12316	1868	2224	
	start	12:07			137	12317	1869		
	end	12:30	34° 58.15	36° 23.37	137	12404	1956	2346	
	start	12:30			138	12405	1957		
	end	12:54	34° 59.60	36° 22.87	138	12492	2044	2438	
	start	12:54			139	12493	2045		
	end	13:17	35° 01.21	36° 22.31	139	12580	2132	2592	
	start	13:17			140	12581	2133		
	end	13:41	35° 02.84	36° 21.81	140	12668	2200	2708	
	start	13:41			141	12669	2201		
	end	14:05	35° 05.62	36° 20.57	141	12756	2308	2904	
	start	14:05			142	12757	2309		
	end	14:34	35° 06.72	36° 20.57	142	12844	2396	3065	
	start	14:34			143	12845	2397		
	end	14:57	35° 08.34	36° 20.04	143	12932	2484	3195	
	start	14:57			144	12933	2485		
	end	15:20	35° 09.97	36° 19.49	144	13021	2572	3165	
	start	15:20			145	13022	2573		
	end	15:44	35° 11.65	36° 18.96	145	13109	2660	3806	
	start	15:44			146	13110	2661		
	end	16:07	35° 12.89	36° 17.66	146	13197	2748	3876	
	start	16:07			147	13198	2749		
	end	16:31	35° 12.16	36° 15.85	147	13285	2836	3716	
	start	16:31			148	13286	2837		
	end	16:55	35° 10.75	36° 15.38	148	13373	2924	3202	
	start	16:55			149	13374	2925		
	end	17:18	35° 09.42	36° 15.78	149	13461	3012	3065	
	start	17:18			150	13462	3013		
	end	17:41	35° 08.07	36° 16.09	150	13549	3100	2711	
	start	17:41			151	13550	3101		
	end	18:04	35° 06.86	36° 16.36	151	13637	3188	2871	
	start	18:04			152	13638	3189		
	end	18:27	35° 05.50	36° 16.67	152	13725	3276	2698	
	start	18:27			153	13726	3277		
	end	18:50	35° 04.20	36° 16.96	153	13813	3364	2294	
	start	18:50			154	13814	3365		
	end	19:13	35° 02.93	36° 17.18	154	13901	3452	2171	
	start	19:13			155	13902	3453		
	end	19:37	35° 01.51	36° 17.46	155	13989	3540	1823	
	start	19:37			156	13990	3541		
	end	20:00	35° 00.17	36° 17.81	156	14077	3628	1846	
	start	20:01			157	14078	3629		
	end	20:24	34° 58.85	36° 18.08	157	14165	3716	1854	

J.D.	start/ end	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Depth (m)	Comments
	start	20:24			158	14166	3717		
		20:46			158	14247			CRU crash at 2046: rebooted
		21:10	~34° 55.595	36° 18.754	1	14339	1		BOT #1 line 1b
	end	21:33	34° 54.744	36° 19.026	1	14426	88	1802	
	start	21:34			2	14427	89		
	end	21:57	34° 53.609	36° 19.275	2	14514	176	1784	
	start	21:57			3	14515	177		
		22:18				14593			Passing waypoint 1.15
	end	22:20	34° 52.1992	36° 19.5921	3	14602	264	1762	
	start	22:21			4	14603	265		
	end	22:44	34° 50.864	36° 19.874	4	14689	352	1753	
	start	22:44			5	14690	353		
	end	23:07	34° 49.4767	36° 20.1945	5	14778	440	1825	
	start	23:08			6	14779	441		
	end	23:31	34° 48.1472	36° 20.5111	6	14866	528	1789	
	start	23:31			7	14867	529		
		23:38				14893			Passing waypoint 1.16
	end	23:54	34° 46.7810	36° 20.7977	7	14954	616	1856	
	start	23:54			8	14955	617		
						14995			Shots not recorded. Truetime
						14996	657		shot error
310	end	00:18	34° 45.4666	36° 21.1176	8	15043	704	1936	Start of 11/5/96
	start	00:18			9	15044	705		
	end	00:42	34° 44.3939	36° 20.2838	9	15131	792	2150	
	start	00:42			10	15132	793		
	end	01:05	34° 44.3489	36° 18.4838	10	13219	880	1857	
	start	01:05			11	15220	881		
	end	01:28	34° 45.1765	36° 17.3363	11	15307	968	1942	
	start	01:29			12	15308	969		
		01:34			12	15326			Gun #12 operational.
	end	01:52	34° 46.8254	36° 16.8348	12	15395	1056	1759	
	start	01:52			13	15396	1057		
	end	02:16	34° 48.3748	36° 16.2863	13	15483	1144		
	start	02:16			14	15484	1145	1600	
		02:36	34° 49.7076	36° 15.9490	14	15559	1220		Passing waypoint 1.19
	end	02:39	34° 49.9239	36° 15.9125	14	15571	1232		
	start	02:40			15	15572	1233	1479	
	end	03:03	34° 51.5097	36° 15.4971	15	15659	1320		
	start	03:03			16	15660	1321	1461	
		03:12			16	15693	1354		Got PLABEL from CSRU.
	end	03:26	34° 53.0615	36° 15.1063	16	15747	1408		
	start	03:26			17	15748	1409	1532	SQTP error 84; bad file?
		03:27			17	15750	1411		SQTP error 84; bad file?
	end	03:50	34° 54.6286	36° 14.7147	17	15835	1496		
	start	03:50			18	15836	1497	1646	
		03:51	34° 54.7378	36° 14.6787	18	15841	1502	1724	Passing waypoint 1.20.
	end	04:13	34° 56.1173	36° 14.0153	18	15923	1584		
	start	04:13			19	15924	1585	1783	
	end	04:37	34° 57.6375	36° 13.3074	19	16011	1672		

J.D.	*start/ end*	*Time (Z)*	*Latitude (Start/End)*	*Longitude (Start/End)*	*Tape #*	*Shot #*	*File #*	*Depth (m)*	*Comments*
	start	04:37			20	16012	1673	1809	
	end	05:00	34° 59.2335	36° 12.5661	20	16099	1760		
	start	05:00			21	16100	1761	1783	C/C 323°.
	end	05:24	35° 00.5358	36° 13.4758	21	16187	1848		
	start	05:24			22	16188	1849	1648	
	end	05:47	35° 01.7172	36° 14.7818	22	16275	1936		
	start	05:47			23	16276	1937	1867	
	end	06:10	35° 03.0318	36° 15.8761	23	16363	2024	1672	
	start	06:10			24	16364	2025		
		06:16				16385			Turn completed; gun #6 pulle
		06:30							Turn to port
	end	06:33	35° 04.3575	36° 15.153	24	16451	2112	1566	
	start	06:34			25	16452	2113		
	end	06:57	35° 05.2816	36° 15.8702	25	16539	2200	2332	
	start	06:57			26	16540	2201		
						16537			SQTP error; bad file?
	end	07:20	35 ° 04.3392	36° 16.7985	26	16627	2288	2323	
	start	07:21			27	16628	2289		
		07:24							Gun #6 operational
	end	07:44	35° 03.0114	36° 17.1961	27	16715	2376	2223	
	start	07:44			28	16716	2377		
						16743			Clock time error:
									shot seg: 16738,39,27,28,
									43,44...
	end	08:08	35° 01.7162	36° 17.4967	28	16804	2464	1827	file seg: 2399,400,388,389,
	start	08:08			29	16805	2465		403,404...
	end	08:31	35° 00.4162	36° 17.7864	29	16892	2552	1798	
	start	08:31			30	16893	2553		
	end	08:54	34° 59.0896	36° 18.0971	30	16980	2640	1759	
	start	08:55			31	16981	2641		
	end	09:18	34° 57.6926	36° 18.3586	31	17068	2728	1843	
	start	09:18			32	17069	2729		
		09:30				17110			Passing waypoint 1.14
	end	09:41	34° 56.3410	36° 18.6822	32	17156	2816	1859	
	start	09:42			33	17157	2817		
	end	10:05	34° 54.986	36° 18.954	33	17244	2904	1804	
	start	10:05			34	17245	2905		
	end	10:29	34° 53.634	36° 19.258	34	17332	2992	1783	
	start	10:29			35	17333	2993		
	end	10:53	34° 52.255	36° 19.582	35	17421	3080	1771	
	start	10:53			36	17422	3081		
	end	11:16	34° 50.922	36° 19.864	36	17509	3168	1726	
	start	11:16			37	17510	3169		
	end	11:40	34° 49.557	36° 20.222	37	17597	3256	1889	11:32 passing wp 1.15
	start	11:40			38	17598	3257		
	end	12:03	34° 48.39	36° 20.194	38	17685	3344	1701	
	start	12:03			39	17686	3345		
	end	12:26	34° 48.293	36° 18.444	39	17826	3432	1982	
	start	12:26			40	17827	3433		

Appendix 15 EW9608 MCS Line Log

J.D.	start/ end	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Depth (m)	Comments
	end	12:40	34° 49.212	36° 15.819	40	17826	3485	1513	
	start	12:40			41	17827	3486		
	end	13:04			41	17913	3572		
	start	13:04			42	17914	3573		
	end	13:27	34° 49.816	36° 14.239	42	18001	3660	1578	
	start	13:27			43	18002	3661		
	end	13:50	34° 50.964	36° 12.477	43	18090	3748	1633	
	start	13:51			44	18091	3749		
	end	14:14	34° 51.193	36° 10.575	44	18178	3836	2016	
	start	14:14			45	18179	3837		14:15 begin turn for E-W line
	end	14:37	34° 52.424	36° 10.365	45	18266	3924	2044	
	start	14:37			46	18267	3925		14:42 end turn
	end	15:01	34° 52.711	36° 12.083	46	18354	4012	1907	
	start	15:01			47	18355	4013		
	end	15:24	34° 52.935	36° 13.736	47	18442	4100	1809	
	start	15:25			48	18443	4101		
	end	15:48	34° 53.096	36°15.522	48	18530	4188	1475	
	start	15:48			49	18531	4189		
	end	16:11	34° 53.436	36° 17.303	49	18618	4276	1939	
	start	16:12			50	18619	4277		
	end	16:35	34° 53.833	36° 19.511	50	18706	4364	1783	
	start	16:35			51	18707	4365		
	end	16:58	34° 54.148	36° 21.104	51	18794	4452	1906	
	start	16:58			52	18795	4453		
	end	17:22	34° 54.481	36° 22.996	52	18882	4540	1756	
	start	17:22			53	18883	4541		
	end	17:45	34° 54.814	36° 24.768	53	18970	4628	2234	
	start	17:45			54	18971	4629		
	end	18:09	34°55.0727	36° 26.4585	54	19058	4716	2159	
	start	18:09			55	19059	4717		
	end	18:32	34° 55.4542	36° 28.3385	55	19146	4804	1753	
	start	18:32			56	19147	4805		
	end	18:56	34° 55.6847	36° 30.1915	56	19234	4892	2130	
	start	18:56			57	19235	4893		
	end	19:19	34° 56.0550	36° 32.0826	57	19322	4980	1727	
	start	19:19			58	19323	4981		
	end	19:43	34° 56.329	36° 33.899	58	19410	5068	1626	
	start	20:29			59	19411	5069		
	end	20:06	34° 56.6393	36° 36.7882	59	19498	5156	1888	
	start	20:06			60	19499	5157		
	end	20:30	34° 51.9509	36° 37.7136	60	19586	5244	1696	
	start	20:30			61	19587	5245		
	end	20:53	34° 57.6195	36° 39.4469	61	19673	5331	1717	
	start	20:53			62	19675	5333		
	end	21:16	34° 59.2479	36° 39.1889	62	19762	5420	1793	2100 turn end@sp19699
	start	21:17			63	19763	5421		
	end	21:40	35° 0.7667	36° 38.9204	63	19850	5508	1854	
	start	21:40			64	19851	5509		
	end	22:03	35° 2.4475	36° 38.5644	64	19938	5596	1906	

Appendix 15 EW9608 MCS Line Log

J.D.	start/ end	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Depth (m)	Comments
	start	22:04			65	19939	5597		
	end	22:27	35° 4.079	36° 38.2068	65	20026	5684	2025	
	start	22:27			66	20027	5685		
		22:26			66	20022			passing Waypoint 1.26
		22:39			66				SHot 20073 not recorded
	end	22:50	35° 5.6797	36° 37.6255	66	20114	5772	2021	
	start	22:50			67	20115	5773		
	end	23:14	35° 7.3032	36° 37.0984	67	20202	5860	2056	
	start	23:14			68	20203	5861		
		23:24			68	20241			Passing waypoint 1.27
	end	23:37	35° 8.8945	36° 36.5988	68	20290	5948	2117	
	start	23:37			69	20291	5949		
	`	23:59	35° 10.4001	36° 36.0726	69	20372	6030	2161	Last shot

Appendix 16

Multichannel Data Processing on EW 96-08

c_realtime.stack

```
/users/henkart/bin/sioseis << !
procs segdin prout geom header diskob gather nmo stack filter diskoa end

segdin
  ffilen 99999   # take all shots (this is the preset!)
  ftr 1 ltr 160  # skip the auxilliary channels - 161-172 and 161-180
  secs 10.0      # the DMS-2000 has garbage from the even second to the end
  decimf 2       # decimate from 2 to 4 ms.  Little energy above Nyquist!
  offline 1      # eject after the rewind after EOT
  iunit 3        # 3480 scsi buse 3
  stime 3.0
  secs 6.0 end
end

prout
# print the stacked trace number just so the light blink!
 fno 0 lno 99999 ftr 1 ltr 1 end
end

geom
# shot spacing of ~33 m (dfls), 12.5 m cdp bins, 25 group spacing
# range to closest trace varies.
# bird/depth sensors change on every deployment
  type 2         # increment the shot loaction based on the shot number
  fs 1 ls 999999  # all shot have the same parameters (preset)
  gxp 160 -263   # RESET the closest group only.
  ggx -25        # Used to extrapolate gxp!
  dfls 30.0 dbrps 12.5 smear 12.5 end
end

header
  l10 l10 * -1 # make ranges positive
  l6 l6 + 200  # make rp numbers positive
  r50 r54 / 750.  # convert water depth to water time
  fno 1 lno 9999999 end
end

diskob
# write every 15th shot to a "circular" file
  fno 1 lno 999999 noinc 15 rewind 1 opath shot.file end
end

gather
# Scratch file parameters, really 2250 4 byte wrds, maxtrcs of 40, pad to be safe
# Roughly 150 MB scratch file
  maxrps 165 nwrds 1600 maxtrs 80 end
end

nmo
# real time nmo, replace interpolation by RP to WB depth in Meters.
```

```
# If water depth changes by > 500 m, use previous value. Water-depth
# velocity functions derived from ESP5, interpolation by iso-velocity layering
 vtrkwb 500 stretc 0.20
 fno 1000 lno 1000
 vtp 1500 1.333
     1557 1.414
     1607 1.443
     1789 1.492
     2346 1.645
     2638 1.746
     2900 1.846
     2971 1.872
     3150 1.983
     3141 2.102
     3264 2.362
     4228 3.742
     4343 3.892
     4898 4.393 end
 fno 1500 lno 1500
 vtp 1500 2.0
     1539 2.081
     1574 2.110
     1705 2.159
     2137 2.312
     2379 2.413
     2603 2.513
     2665 2.539
     2827 2.650
     2834 2.769
     2967 3.029
     3939 4.409
     4053 4.559
     4596 5.060 end
 fno 2000 lno 2000
 vtp 1500 2.667
     1529 2.748
     1557 2.777
     1659 2.826
     2012 2.979
     2218 3.080
     2414 3.180
     2468 3.206
     2614 3.317
     2629 3.436
     2761 3.696
     3711 5.076
     3823 5.226
     4351 5.727 end
 fno 2500 lno 2500
 vtp 1500 3.333
     1524 3.414
     1546 3.443
     1629 3.492
     1928 3.645
```

2108 3.746
2282 3.846
2330 3.872
2463 3.983
2481 4.102
2608 4.362
3526 5.742
3636 5.892
4146 6.393 end
fno 3000 lno 3000
vtp 1500 4.0
1520 4.080
1538 4.110
1609 4.159
1868 4.312
2028 4.413
2184 4.513
2228 4.539
2350 4.650
2368 4.769
2489 5.029
3373 6.409
3479 6.559
3972 7.060 end
fno 3500 lno 3500
vtp 1500 4.667
1517 4.748
1533 4.777
1595 4.826
1823 4.979
1967 5.080
2108 5.180
2148 5.206
2260 5.317
2279 5.436
2395 5.696
3243 7.076
3346 7.226
3822 7.727 end
fno 4000 lno 4000
vtp 1500 5.333
1515 5.414
1529 5.443
1583 5.492
1788 5.645
1919 5.746
2048 5.846
2085 5.872
2189 5.983
2208 6.102
2317 6.362
3131 7.742
3231 7.892
3692 8.393 end

```
 fno 4500 lno 4500
 vtp 1500 6.0
    1513 6.081
    1526 6.110
    1574 6.159
    1760 6.312
    1879 6.413
    1999 6.513
    2033 6.539
    2130 6.650
    2148 6.769
    2252 7.029
    3034 8.409
    3131 8.559
    3577 9.060 end
 fno 5000 lno 5000
 vtp 1500 6.667
    1512 6.748
    1523 6.777
    1567 6.826
    1737 6.979
    1847 7.080
    1958 7.180
    1990 7.206
    2080 7.317
    2098 7.436
    2197 7.696
    2948 9.076
    3042 9.226
    3474 9.727 end
end

filter
 pass 5 40 dbdrop 24 ftype 0 end
end

diskoa
# Write out disk file
 opath stack.line1 end
end

end
!
```

c_tapecopy

```
/users/henkart/bin/sioseis << !
procs segdin prout output end

segdin
  ffilen 99999   # take all shots (this is the preset!)
  ftr 1 ltr 160  # skip the auxilliary channels - 161-172 and 161-180
  secs 10.0      # the DMS-2000 has garbage from the even second to the end
  decimf 2       # decimate from 2 to 4 ms.  Little energy above Nyquist!
  offline 1      # eject after the rewind after EOT
  tr0 1          # write trace 0 to tape
  iunit 3 end    # 3480 scsi buse 3
end

prout
 fno 0 lno 99999 ftr 1 ltr 1 end # print the stacked trace number
end

output
  ontrcs 160     # reinforce that only 160 traces are to be written
  rewind 0       # leave the tape alone!
  ounit 4 end    # write to DAT buse 4
end

end

!
```

Appendix 17

GPS Navigation and Data Logging on EW 96-08

1. Positioning of Sensors

The sonars and other sensing instruments used on Ewing were not directly under the GPS antenna. The displacement of each of the sensors with respect to the GPS antenna is as follows:

-Magnetometer	about 280 m aft
-3.5 kHz	6 m aft
-Hydrosweep	14 m aft
-Gravimeter	1 m aft

2. Ewing Data-Logging System

The main logging system is built around a Sun SPARC2 workstation running the SUNOS 4.1 UNIX operating system. From this computer, RE-232C serial lines go to the serial port of each of the instruments logged (e.g., GPS receiver, gravimeter). Each type of instrument has its own separate and slightly specialized program. Each data-record output by an instrument is captured, time-stamped with the CPU's current time, and appended to the current daily file for that instrument. The GPS clock is also logged and the CPU clock is updated to UTC time each minute. The CPU time-tags are used for data from the Furuno speed log, BGM-3 gravimeter, magnetometer, pitch-roll, and Hydrosweep bathymetry. The GPS data records are also time tagged with the CPU time but the time of position comes from the times established by the receiver for the position.

The Sun workstation logs all data directly except for the Hydrosweep data. The Hydrosweep has a Silicon Graphics (SGI) Personal Iris workstation as its direct-interface computer. The SGI workstation sends to Hydrosweep the navigation collected from the network broadcast, reads the Hydrosweep's output data, and broadcasts these data on the network. The Sun computer logs these Hydrosweep data broadcasts on its disk.

Daily data reduction generally started shortly after GMT midnight, and post-processed navigation, gravity free-air anomaly, magnetic anomaly, and center-beam bathymetry were available within 3-4 hours. Data reduction was carried out by Budhy Budhypramono on a Sun workstation.

3. True Time Clock

Instrument: Kinematics GPS Synchronized clock, Model GPS-DC
Logging: 60 second intervals
Note: The True Time clock is used to adjust the CPU clock of the logging computer. The logging computer captures the continuous time records from the clock and provides these as a service to the rest of the network via a UDP broadcast. This enables the computers on the network to adjust their CPU times to UTC time.

4. Speed and Heading

Instrument: Furuno CI-30 2-axis doppler speed log; Sperry MK-27 gyro
Logging: 3 second intervals
Checking: Visual check of plots of data
Smoothing: Mean value of all good values within the same minute

5. GPS Satellite Fixes

Primary satellite fixes of ship position was from three separate GPS (Global Positioning System) devices: Trimble NT200D (1 receiver), Magnavox MX4200D (2 receivers), and Ashtec GG24 GPS(US satellites)_GLONASS(Russian satellites) (1 receiver). Together these three independent systems provided good GPS navigation generally for 24 hours per day. Dead reckoning based on Furuno speed and heading data was used to cover any small gaps in the GPS navigation.

Instruments: Trimble NT200D GPS receiver
Ashtec GG24 GPS_GLONASS receiver
Magnavox 4200D (receivers 1 and 2)

Data ID: "gp1" = GPS Trimble NT200D
"gp2" = GPS_GLONASS Ashtec GG24
"gp3" = GPS Magnavox MX4200D Receiver 1
"gp4" = GPS Magnavox MX4200D Receiver 2

Logging: 10 second intervals on all four receivers

Checking: *GPS-MX 4200 1&2 receivers, GPS Trimble NT200D receiver*
1) Minimum number of sats: 3
2) Dilution of precision (DOP) maximum: north-4.0, east=4.0
3) Speed maximum: 20.0
4) Compare GPS speed and course with Furuno smooth speed and heading
5) Reject fixes with high drifts in navigation
6) Reject fixes producing Eotvos correction errors in gravity > 5 mGals

Checking: *Ashtec GG24 GPS_GLONASS receiver*
1) Minimum number of GPS sats: 4
2) Minimum number of GLONASS sats: 2
3) Dilution of precision (DOP) maximum: north-2.0, east=2.0
4) Speed maximum: 15.0
5) Compare GPS speed and course with Furuno smooth speed and heading
6) Reject fixes with high drifts in navigation
7) Reject fixes producing Eotvos correction errors in gravity > 5 mGals

Interpolation: Interpolated positions at 00, 30 seconds of each minute

Smoothing: Smoothed interpolated positions with 9-point running average

Note: The Selective Availability (SA) enforced by the Department of Defense (DoD) causes us to take a GPS fix every twenty minutes, and dear reckoning (DR) in between. During EW 96-08 we experimented with a GPS_GLONASS receiver. The major difference in implementation between GPS and GLONASS are that GPS has SA on both C/A and P codes, i.e., the codes are deliberately degraded by dithering the transmit time. GLONASS, on the other hand, has no deliberate degradation. This in turns allow us to use the GPS_GLONASS derived fixes at one minute interval. During the time when GPS_GLONASS receiver was down, a twenty minute GPS MX-4200 fixes and DR were used.

6. Navigation

A 1-minute navigation was produced from the shipboard GPS and Furuno sources. The smoothed speed and heading data are used to fill the gaps between the processed GPS position by computing 1-minute dead-reckoned position corrected for set and drift. The dead-reckoned positions are produced at 00 seconds of each minute. Final navigation used the GPS+GLONASS or GPS MX-4200 and DR data sets.

7. Shot Time and Gun Depth

Instrument: LDEO Time Tagger and Gun Depth Interface

Logging: Short time from the Time Tagger. Gun depth from Gun Depth Interface

Appendix 18

Multibeam Processing on EW 96-08

1. Center-Beam Bathymetry

Instrument: Krupp Atlas Hydrosweep DS
Logging: Every ping
Sound velocity: Center beam depths were calculated using the travel times and a sound velocity of 1500 meter per second.
Checking: Visual check of plot of data. Bad data points removed with an interactive graphics editor. Iteration 1 - First pass through beam-point data, ping-by-ping, eliminating obviously bad data points. Iteration 2 - The edited data were plotted as swath plots, and these plots were checked for further errors; identified errors were then flagged in a second pass of the beam editing with interactive graphics editor.
Final data: Interpolated depth value in meters at 00 seconds of each minute

2. Hydrosweep Multibeam Bathymetry

(1) Overview

Hydrosweep is a 15-kHz multi-narrow-beam echosounding system that maps a seafloor swath nominally equal to twice water depth. For each insonification of the bottom, the system measures the round-trip travel times of 59 beams (29 port, 29 stbd, and 1 at nadir), each of approximately 1.5 degrees angular width, and estimates the depths. The system also logs echo amplitude and duration. An average sound velocity for the water column is used to convert the two-way travel times to estimates of depth and distance across track. The real-time processing estimates a depth and cross-track distance but does not take into account ray path bending due to variations in sound speed.

(2) Performance

The Hydrosweep during EW 96-08 produced a narrower-than-expected swath of multi-beam bathymetry, typically ranging between 1.5 and 1.7 times water depth and averaging ~1.6 times water depth (these values were measured from typical swath plots on maps). Beam drops (zero values recorded by the Hydrosweep system) averaged 11.81% throughout the survey. Beam flags (bad data points identified using an interactive beam-point editor) averaged about 4.25%. The majority of the drops and flags were in the outer beams on both port and starboard sides. As a result, the Hydrosweep returned 84% "good data" during this cruise (Figure A18.1).

(3) Bathymetry Processing

Processing and editing of Hydrosweep data were carried out by Allegra Hosford and Jian Lin daily during EW 96-08. Typically it took 2-4 hours to process a day of Hydrosweep data. Hydrosweep processing includes the following steps:

1) Create a sound-velocity profile (SVP) within the MB-System using an area-appropriate XBT (see next section on Sound-Velocity Corrections).
2) Run "mbm_process1" for initial processing of a daily hs (Hydrosweep) file. This program copies the raw hs file to the current working directory for interactive editing or final processing. The program converts Hydrosweep travel time to bathymetry using the specified SVP, runs first-pass automated cleaning to eliminate the most obvious bad points, and creates a ".bc.mb24" file for further processing.
3) Run "mbedit" to manually flag bathymetric artifacts in the ".bc.mb24" file. This program flags bad points by setting depth values less than zero so that no information is irretrievably lost. The "mbedit" was used only for data in the study

area during JD292-321 (10/18-11/16/96), i.e., non-transit days. The program creates a ".bce.mb24" file.

4) Run "mbm_process2" for final processing of the ".bce.mb24" file. This program merges the final navigation data with the output from the "mbedit" program, generates a hs swath map both in ".ps" and ".rtl" formats for plotting in the NovaJetII plotter in the Ewing after lab, and creates the final ".bcen.mb24" file. Hydrosweep data from transit days (JD288-291 and 322-325/6) were edited using the above procedure except for hand-editing using the "mbedit" program.
5) Compress all processed data files and archive them by date.

(4) Sound-Velocity Corrections

The bathymetry and range information generated by the Hydrosweep DS system are computed from travel times and angles combined with a mean sound velocity for the entire water column. While this yields satisfactory results for real-time display, a more precise solution can be obtained by using a layered-model approach to correct for ray path bending. In order to use this technique, it is necessary to first construct an accurate sound velocity profile (SVP). This was accomplished by combining the regional Levitus data base and spot measurements using XBT (expendable bathythermograph) probes. The SVPs derived from XBT and Levitus generally agreed on the order of +/- 2 meters per second. Joe Stennett and Chuck Donaldson took a XBT measurement in each of the study areas during EW 96-08 (Figure A18.2). A composite SVP for a day was generated as follows:

1) Run "mbm_xbt" on raw XBT data to convert depth-temperature information to depth-sound velocity information. This program creates a ".sv" file.
2) Run "mblevitus" to generate a mean water velocity profile for a specified 1°x1° region using the Levitus temperature and salinity data base. The output depth profile reflects the mean annual water column structure for that region.
3) Run "mbcopy" on the raw Hydrosweep file to extract the travel time information for periods before and after the time at which the XBT was performed. Run "mbedit" on this file to remove bad pings.
4) Run "mbvelocitytool" to construct a raw SVP that is consistent with the XBT, Levitus, and travel time data (i.e., steps 1-3 above). Bathymetry values are calculated by tracing the ray paths through the SVP for each beam. The "mbvelocitytool" program interpolates between depth-velocity pairs. The resulting SVP is then used by the "mbm_process1" program.

The composite SVP files were used for following days of Hydrosweep editing:

SVP 292:	JD292-293
SVP 294:	JD294, 309-317
SVP 295:	JD295-297, 307-308
SVP 298:	JD298-302
SVP 303:	JD303-306
SVP 318:	JD318-321

(5) Roll and Pitch Bias

In order to compensate for the discrepancy between the mounting of the Vertical Reference Unit (VRU) and Hydrosweep DS transducers, it is necessary to add a Roll and Pitch Bias value into the Hydrosweep system. The Roll Bias is determined by surveying across a patch of sea floor with a constant slope, using pairs of survey lines in opposite directions. The difference in slope in opposite directions is twice the Roll Bias. Previous testing of Ewing resulted in determination of a Roll Bias of +0.15 degrees, which was entered into the Hydrosweep processor.

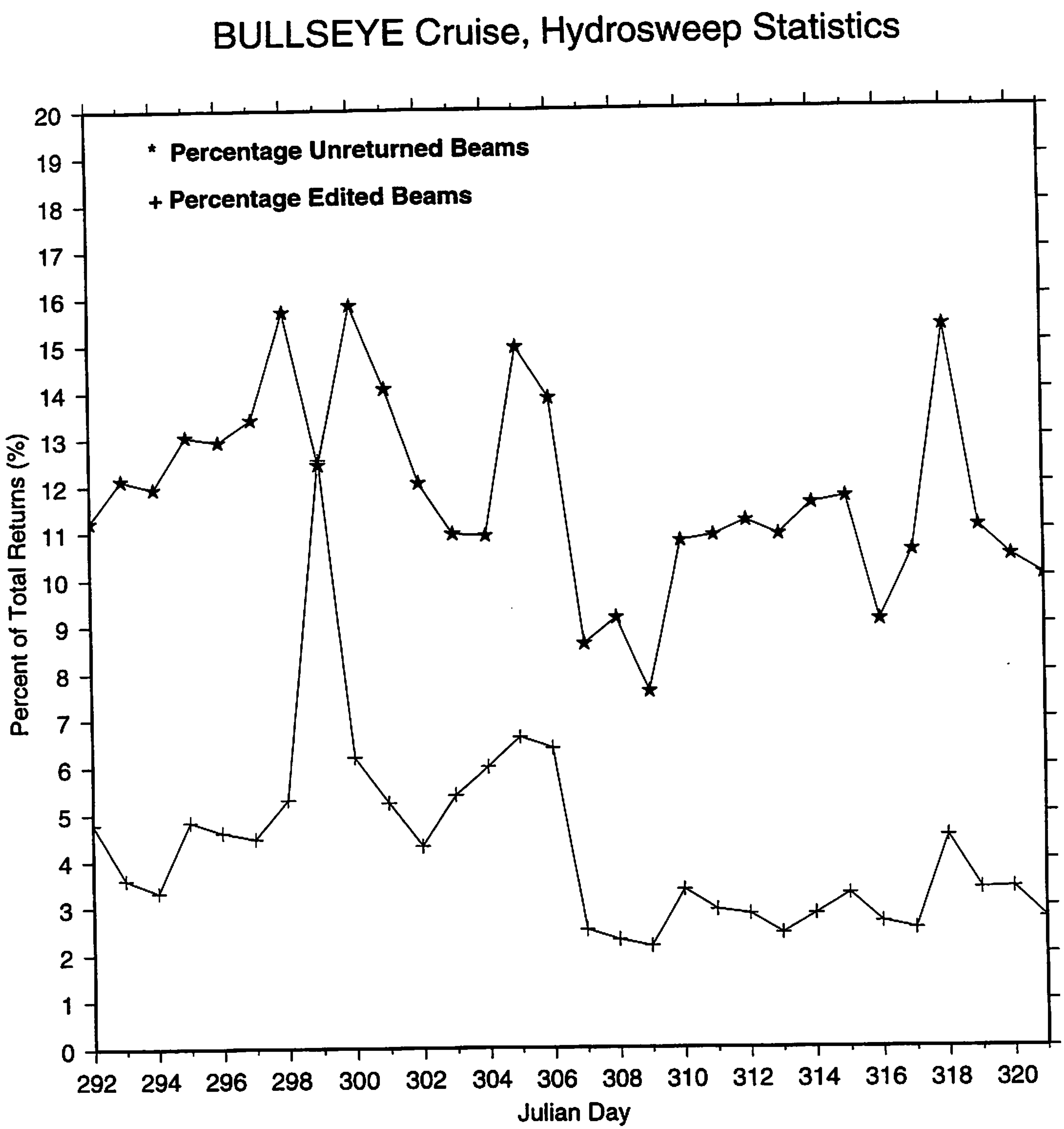
The Pitch Bias is determined by surveying up and down a constant slope. The offset between uphill and downhill isolines is used to determine the Pitch Bias. Previous testing on Ewing resulted in determination of Pitch Bias of +1.67 degrees, which was also entered into the Hydrosweep processor.

(6) Time Corrections

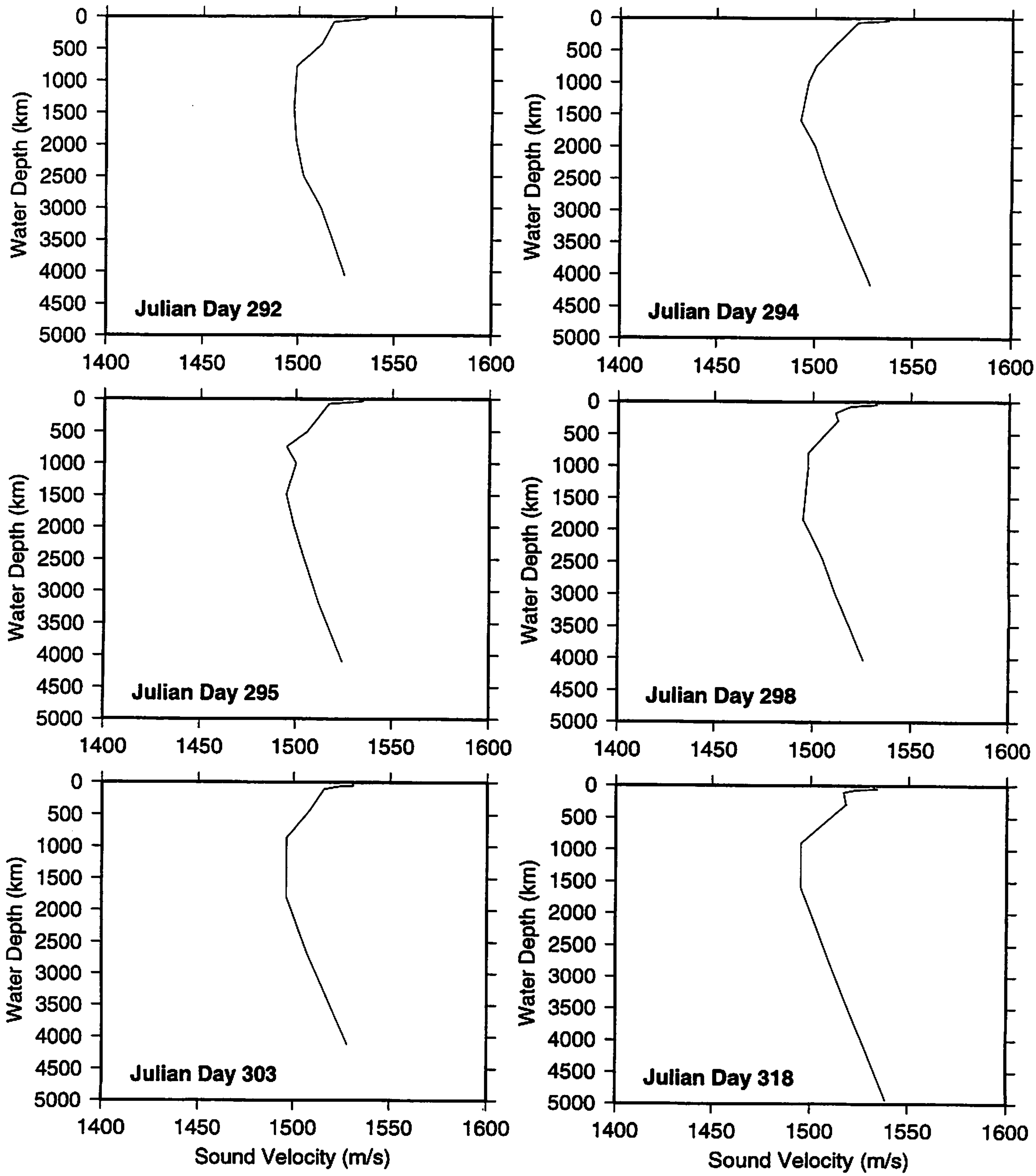
The time associated with each ping is set by the Hydrosweep processor, which is fed the correct UTC time from the LDGO data logging system. The host computer that performs this function receives time updates and corrections via a GPS-based clock. No further corrections to the Hydrosweep ping time are anticipated.

(7) Beam-Amplitude Date

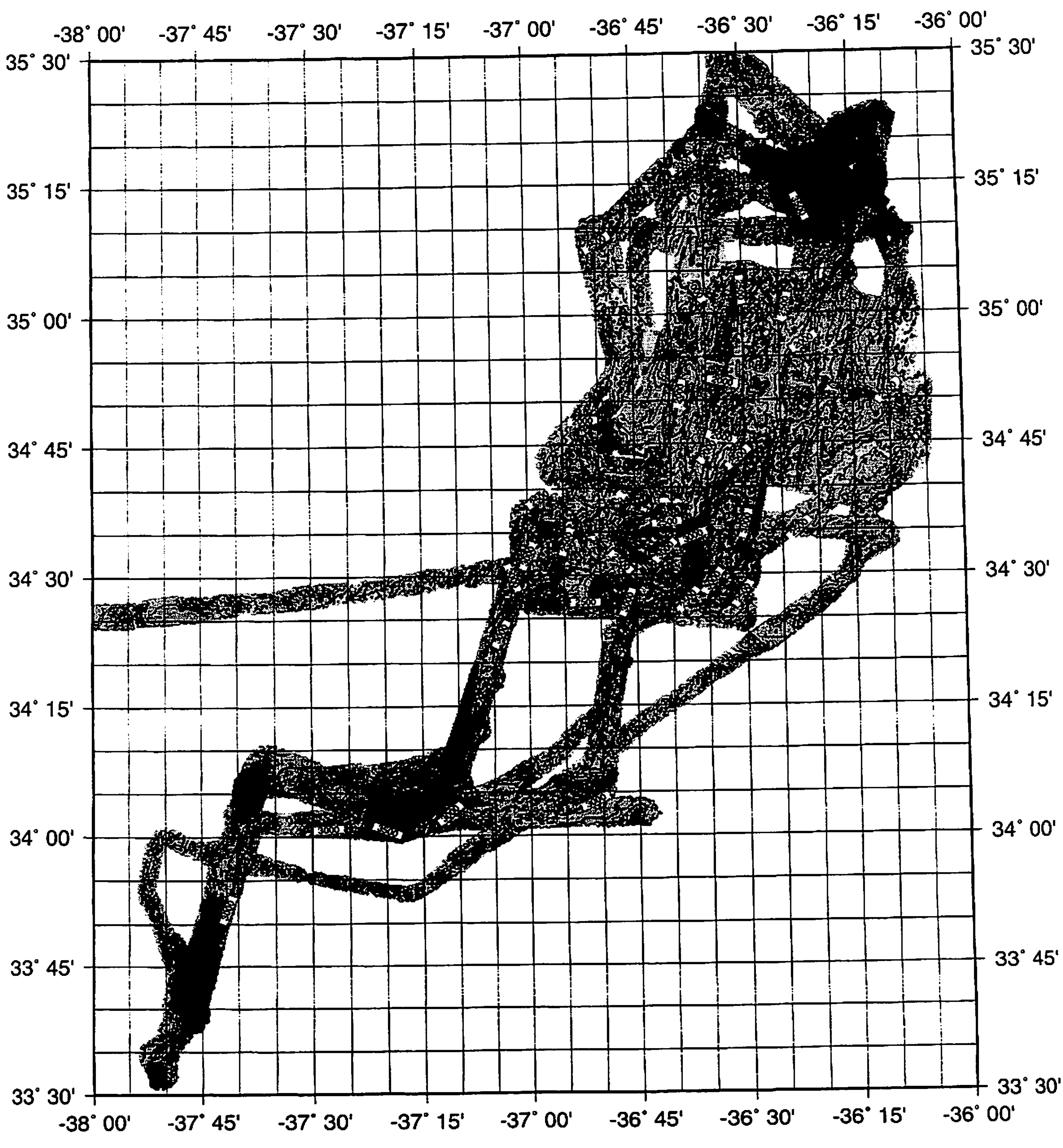
In addition to the travel-time data generated for the determination of bathymetry, the Hydrosweep DS system produces an eight-bit amplitude value per beam, along with the echo length. At present, there is no standard, established procedure for processing Hydrosweep amplitude data. During previous cruises, for example, EW 96-06, an effort was made to utilize some of the existing processing routines within the MB-System software to see if interesting results could be obtained. Although no such attempt was made during EW 96-08, the data collected might be used in future studies.


BULLSEYE Cruise, Hydrosweep Statistics
* Percentage Unreturned Beams
+ Percentage Edited Beams
Percent of Total Returns (%)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
292
294
296
298
300
302
304
306
308
310
312
314
316
318
320
Julian Day

BULLSEYE Cruise, Sound Velocity Profiles



BULLSEYE Cruise, Hydrosweep Data Gridded at 200m



Appendix 19

Magnetics and Gravity Processing on EW 96-08

1. Magnetics

The magnetic field was recorded using a Varian 75 magnetometer with a bottle towed nominally 280 meters behind the GPS antenna on the ship. Digital recording was provided by the LDEO data logging system, and a paper strip chart record was also obtained. During this cruise, the magnetometer was deployed primarily during periods of air gun shooting for OBH experiments and MCS survey. The system performed well throughout the periods of recording. Approximately 23,193 points of good magnetic anomalies were recorded in the study area (Figure A19.1).

Instrument: Varian V75 magnetometer
Logging: 6 second intervals
Checking: Visual check of plots of data. Bad data points removed with an interactive graphics editor.
Reference field: International Geomagnetic Reference Field 1995 (IGRF 1995) model of the main field at 1995.0 and a predictive model of the secular variation for adjusting to dates between 1995.0 and 2000.0
Residual field: Applied by bi-linear interpolation across a 1 degree square
Final data: Median values at 00 seconds of each minute calculated from the values of +/-30 seconds of this time.
Navigation: "mg1.n" files are based on GPS MX-4200 navigation; "mg2.n" files based on GPS_GLONASS navigation.

2. Gravity

(1) BGM-3 Gravimeter

The gravity field was recorded on a BGM-3 gravimeter. Performance was excellent and trouble-free.

Instrument: Bell Aerospace BGM-3 marine gravity meter
Logging: 1 second intervals
Filtering: An observed gravity in mGal is calculated by filtering the 1-second counts with a 360-second Gaussian filter, scaling the result, and adding a bias. A value in mGal is calculated for 00 seconds of each minute.
Merge with navigation: Calculate Eotvos correction and Free Air Anomaly. The ship velocities (from the navigation) that are used in Eotvos correction are smoothed with a 5-point running average.
Checking: Visual check of plots of data to determine satisfactory Eotvos corrections; delete spikes of data at turns.
DC shift: 23.8 mGal
Final data: Free air anomaly value at 00 seconds of each minute. 1980 theoretical gravity formula.
Navigation: "vt1.n" files are based on GPS MX-4200 navigation; "vt2.n" files based on GPS_GLONASS navigation.

The first gravity tie of the ship gravimeter was made on 13 Oct. 1996 by LDEO Science Officer Joe Stennett at a dock tie-point in St. Johns, Newfoundland. A second gravity tie will be carried out by Stennett in Bermuda on 22 Nov. 1996. It is expected that the total drift of the BGM-3 gravimeter will be less than 0.2 mGal for the entire 39-day cruise (0.03509 mGal/day).

The gravity base stations in St. Johns, Newfoundland and Bermuda are not corrected for the 13.6 mGal "Potsdam error". Therefore the 1980 international formula was used in calculating the free-air anomaly, because this formula has a built-in correction for the Potsdam error.

(2) Free-Air Anomaly

The raw gravity data were reduced to free-air anomaly (FAA) by Budhy Budhypramono using the LDEO software "m_grv.c" (Figure A19.2). This Eotvos reduction procedure corrects for artificial gravity effects due to changes in ship course and speed:

$$eotvos\_corr=7.5038*vel\_east*\cos(lat) + 0.004154*vel^2$$

where vel is ship speed in knots and vel_east is eastward velocity. These velocities were derived from a smoothed GPS+GLONASS or GPS Trimble navigation using software developed at LDEO. The FAA was also corrected for a regional field based on a 1980 theoretical gravity formula:

$$gtheo=978032.7*[1.0+0.0053024*\sin^2(lat)-0.0000058*\sin^2(2*lat)]$$

We note that the "m_grv.c" software also contains an option for the 1967 formula:

$$gtheo=978031.846*[1.0+0.005278895*\sin^2(lat)-0.000023462*\sin^2(2*lat)]$$

and the 1930 formula:

$$gtheo=978049.0*[1.0+0.0052884*\sin^2(lat)-0.0000059*\sin^2(2*lat)]$$

It appears that earlier LDEO cruises have used the 1967 and 1930 formula in calculating free-air anomalies. Since the 1980 formula differs by a constant from the 1930 or 1967 formula, it is important to check the formula used in a specific LDEO survey when merging it with the current study.

(3) Mantle Bouguer Anomaly

The primary purpose of the gravity survey of this cruise is to determine the lateral variations in crustal and mantle density beneath ridge segments and tectonic offsets. To reveal sub-seafloor density features, Jian Lin reduced the free-air anomaly to the mantle Bouguer anomaly (MBA) by removing the gravity effects of water/crust and crust/mantle interfaces. This modeling approach follows that of previous three-dimensional gravity mapping of Kuo and Forsyth (1988) and Lin et al. (1990).

The mantle Bouguer corrections were made based on Hydrosweep bathymetry data collected during this cruise. The gravitational effects of the seafloor topography were calculated using a Fourier Transformation spectrum method of Parker (1972). The initial model assumes a 6-km constant-thickness crust and constant densities for water (1030 kg/m^3), crust (2700), and mantle (3300). The mantle Bouguer anomaly directly reflects deviations from this simple model.

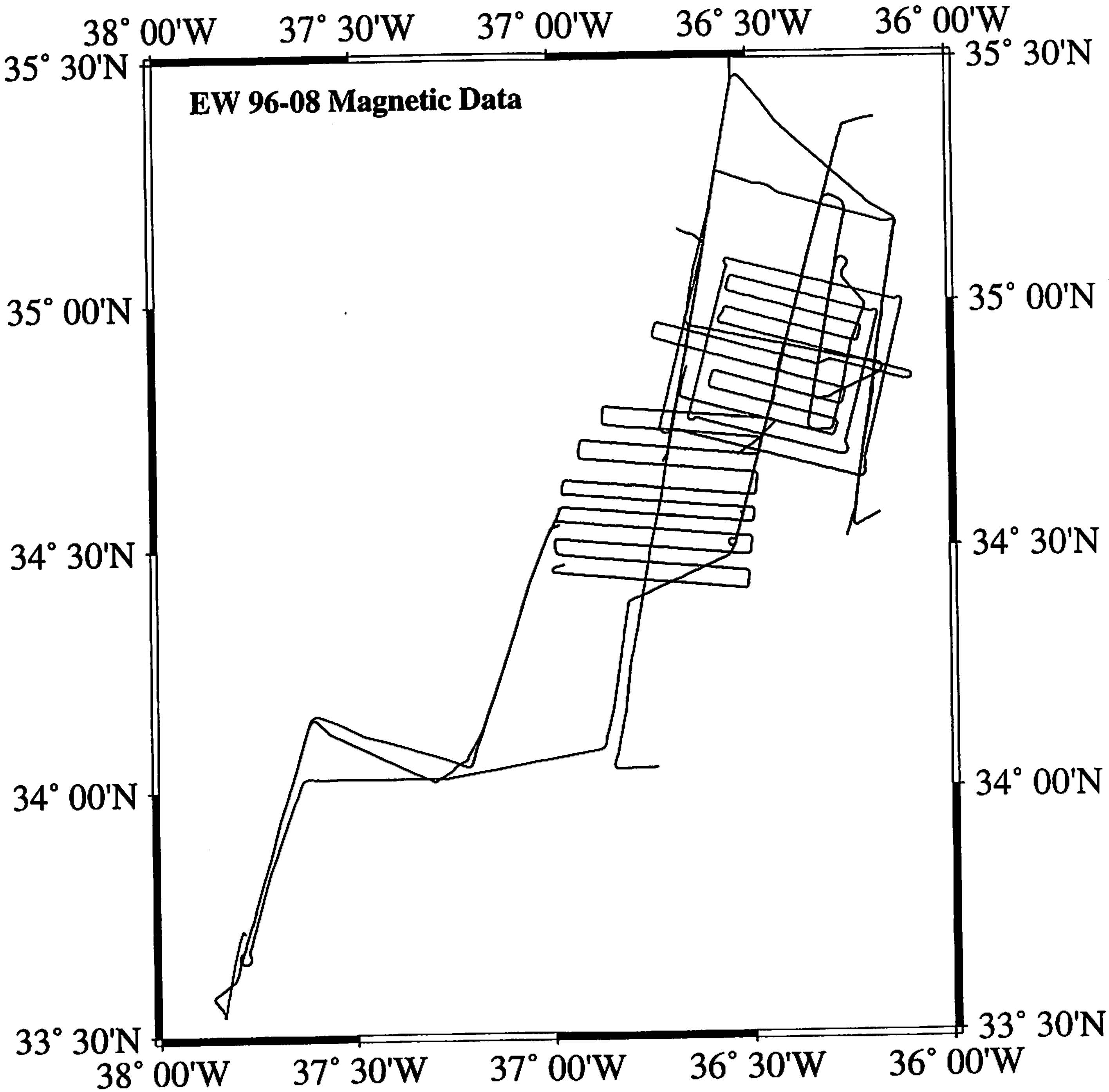
Digital bathymetry in a region (38°-36°W, 33.5°-35.5°N) was transformed into a uniform grid by Allegra Hosford using MB-System and GMT softwares, with longitude and latitude spacings of 0.720313 and 0.870050 km, respectively. For every free-air anomaly measurement g_faa at point P (long, lat), we calculated the mantle Bouguer gravity effect c (long, lat). The mantle Bouguer anomaly at point P is then obtained as

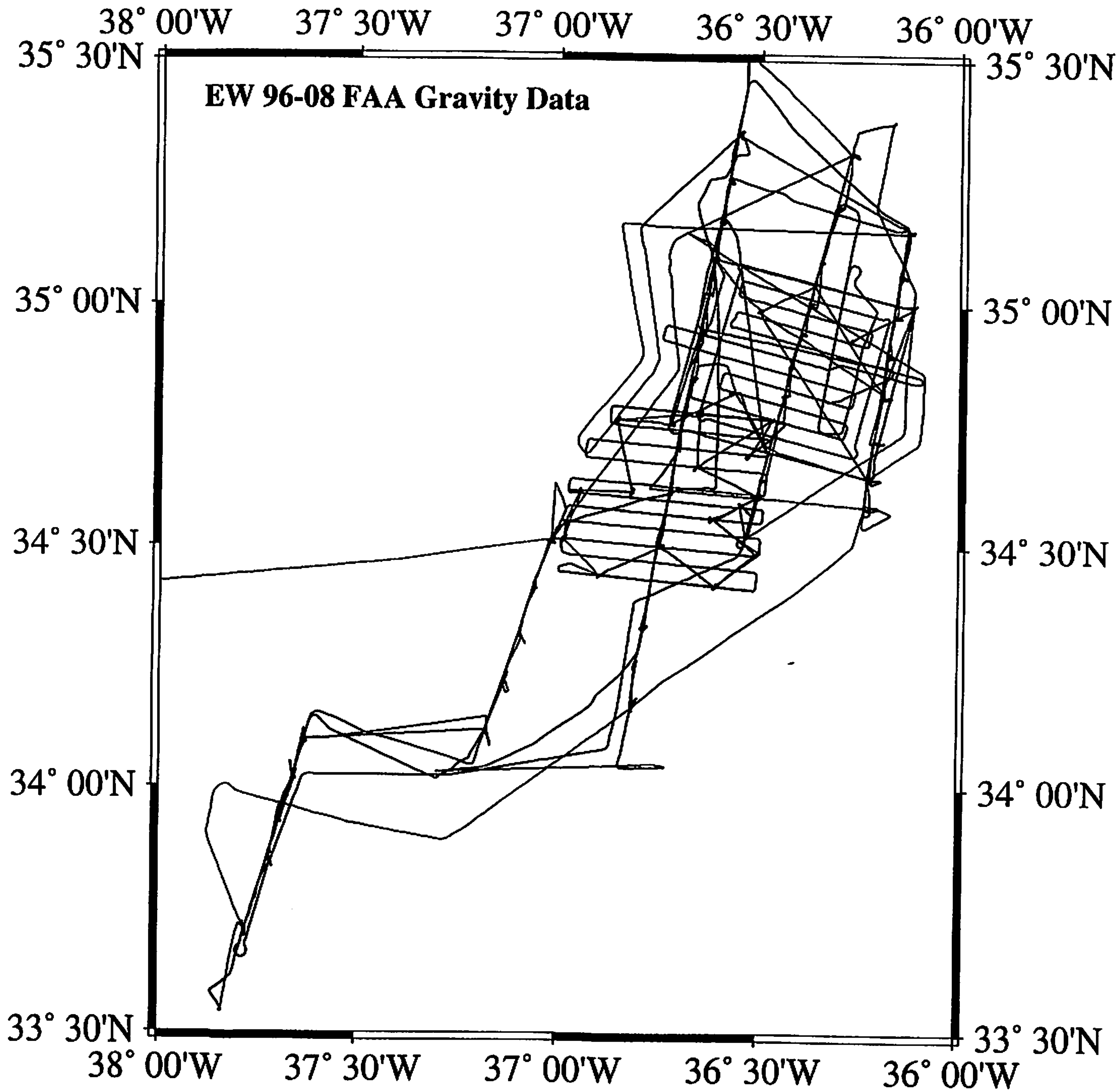
g_mb=g_faa - c(long, lat)

Approximately 42,480 points of good free-air and mantle Bouguer anomalies were obtained using the above method. The mantle Bouguer anomaly increases away from the ridge axis at an average gradient of 0.28 mGal/km.

3. Ewing 3.5 kHz Profiler

Echosounding with hall-mounted EDO 3.5-kHz transducers (12-bottle array), an EDO 550 transceiver, and a 10 kW booster was conducted continuously throughout the cruise. Profilers were recorded on an EPC 9800 Thermal Plotter using an ungated 1-sec sweep. The hard copy profiles were recorded on a plasticized medium, in roll form, and then folded and stored in large envelopes for easy access. The original records were taken to LDEO for archiving. The real-time display of 3.5 kHz was useful in determining bottom topography near planned sites of OBH/MISER drops.


38° 00'W
37° 30'W
37° 00'W
36° 30'W
36° 00'W
35° 30'N
35° 00'N
34° 30'N
34° 00'N
33° 30'N
EW 96-08 Magnetic Data


EW 96-08 FAA Gravity Data
38° 00'W
37° 30'W
37° 00'W
36° 30'W
36° 00'W
35° 30'N
35° 00'N
34° 30'N
34° 00'N
33° 30'N

Appendix 20
EW 96-08 Data List

Test Deployments
1 OBH Receiver Book - OBH 22 Cold Test 10/15/96

2 SONY 112m 8mm tapes, tar format - copies 1 and 2 (8200 density mode) - OBH 22 cold test data, obh22tst.raw; 10/22/96

1 ORB Receiver Book - ORB #1 Test #1 (not deployed but acquisition proceeded without interruption) 10/16/96

1 OBH Receiver Book - OBH 22, ORB #1 Test #1 10/17/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode) - OBH 22 MART01_22, obh22t1.raw; 10/17/96

1 ORB Receiver Book - ORB #1 Test #2 (same as ORB #1 Test #1 from the point of view of OBH ops.)

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode), ORB #1 Test #2 data, test2.ref; 10/20/96

Deployment #1 - MARBE1
10 OBH Receiver Books - OBHs 16-17, 19-20, 22-27

2 ORB Receiver Books - ORBs 2-3

20 SONY 112m 8mm tapes, dd format archive copies 1 and 2 (8200 density mode) - OBHs 16-17, 19-20, 22-27; 10/20/96-10/21/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of *.raw files, OBHs 16-17, 19-20, 22-27; 10/22/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode) of ORB #2 refdump data, ORB2.ref; 10/22/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of segydir; 11/7/96

Deployment #2 - MARBE2
10 OBH Receiver Books - OBHs 16-17, 19-20, 22-27

2 ORB Receiver Books - ORBs 1,4

20 SONY 112m 8mm tapes, dd format archive copies 1 and 2 (8200 density mode) - OBHs 16-17, 19-20, 22-27; 10/23/96-10/24/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of *.raw files, OBHs 16-17, 19-20, 22-27; 10/25/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode) of ORB #1 refdump data, ORB1m2.ref; 10/24/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of segydir; 11/7/96

Deployment #3 - MARBE3

10 OBH Receiver Books - OBHs 16-17, 19-20, 22-27

4 ORB Receiver Books - ORBs 1-4

20 SONY 112m 8mm tapes, dd format archive copies 1 and 2 (8200 density mode) - OBHs 16-17, 19-20, 22-27; 10/28/96-10/29/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of *.raw files, OBHs 16-17, 19-20, 22-27; 11/1/96

6 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode) of ORB #1-3 refdump data, ORB1m3.ref, ORB2m3.ref, ORB3m3.ref; 10/29/96, 10/31/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of segydir; 11/7/96

Deployment #4 - MARBE4

8 OBH Receiver Books - OBHs 16-17, 22-27

16 SONY 112m 8mm tapes, dd format archive copies 1 and 2 (8200 density mode) - OBHs 16-17, 22-27; 10/31/96-11/1/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of *.raw files, OBHs 16-17, 22-27; 11/2/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of segydir; 11/8/96

Deployment #5 - MARBE5

10 OBH Receiver Books - OBHs 16-17, 19-20, 22-27; 3 ORB Receiver Books - ORBs 1-3

20 SONY 112m 8mm tapes, dd format archive copies 1 and 2 (8200 density mode) - OBHs 16-17, 19-20, 22-27; 11/11/96-11/12/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode), default (512) blocksize of ORB #3 refdump data, ORB3m5.ref; 11/11/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode), blocksize 1048576, of ORB #2 refdump data, ORB2m5.ref; 11/11/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode), blocksize 1048576, of ORB #1 refdump data, ORB1m5.ref; 11/12/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of *.raw files, OBHs 16-17, 19-20, 22-27; 11/13/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of segydir; 11/14/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode), of ORB #1 data, *.log, *.err, and segy files; 11/16/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode), of ORB #2 data, *.log, *.err, and segy files; 11/14/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode), of ORB #3 data, *.log, *.err, and segy files; 11/14/96

Deployment #6 - MARBE6

10 OBH Receiver Books - OBHs 16-17, 19-20, 22-27; 3 ORB Receiver Books - ORBs 1-3

20 SONY 112m 8mm tapes, dd format archive copies 1 and 2 (8200 density mode) - OBHs 16-17, 19-20, 22-27; 11/16/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode), default (512) blocksize of ORB #1 refdump data, ORB1m6.ref; 11/16/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode), default (512) blocksize of ORB #2 refdump data, ORB2m6.ref; 11/17/96

2 SONY 112m 8mm tapes, dd format copies 1 and 2 (8200 density mode), default (512) blocksize of ORB #3 refdump data, ORB3m6.ref; 11/16/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of *.raw files, OBHs 16-17, 19-20, 22-27; 11/17/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode), of ORB #1 data, *.ref, *.log, *.err, and segy files; 11/16/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode), of ORB #2 data, *.ref, *.log, *.err, and segy files; 11/17/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode), of ORB #3 data, *.ref, *.log, *.err, and segy files; 11/17/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of segydir; 11/18/96

Miscellaneous Cruise Data

1 Notebook of Test Deployment, MARBE1, MARBE2, MARBE3 OBH Datafile Headers (obh_rec_hdrs output)

1 Notebook of MARBE4, MARBE5, MARBE6 OBH Datafile Headers (obh_rec_hdrs output)

1 Booklet summarizing parameters used in obh_to_segy runs.

1 Notebook summarizing multibeam editing sessions and other processing steps.

1 SONY 112m 8mm tape, tar format copy (8200 density mode) of jh directory, ORB test data; 11/9/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of /jade2 bullseye, ORB data up to MARBE5; 11/9/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of /jade0 directories, bullseye, grnlnd, obh_locate, obs_melt; prior to MARBE5 recoveries; 11/10/96

2 SONY 112m 8mm tapes, tar format copies 1 and 2 (8200 density mode) of /jade1 directories, grnlnd, bullseye; prior to MARBE5 recoveries; 11/10/96

231 MCS Nav and Data cartridges:
- Box 1) Data tapes 1-30
- Box 2) Data tapes 31-60
- Box 3) Data tapes 61-90
- Box 4) Data tapes 91-120
- Box 5) Data tapes 121-150

Box 6) Data tapes 151-158,1*-22*
Box 7) Data tapes 23*-52*
Box 8) Data tapes 53*-69*,
Navigation Tape #1, JD 308, 11/3/96, Line 1a, Reels 1-66, Files 1-5747
Nav Tape #2, end JD 309, 11/4/96, 10:35z
Nav Tape #1, end JD 310, 11/5/96, 12:40z
Nav Tape #2, end JD 311, 11/6/96, 00:00z

7 120m DDS-2 data cartridge copies of MCS data:
1) Tapes 1-35, SPS 413-3494
2) Tapes 36-70, SPS 3495-6515
3) Tapes 71-105, SPS 6516-9625
4) Tapes 106-140, SPS 9626-12668
5) Tapes 141-158,1*-17*, SPS 12669-15835
6) Tapes 18*-52*, SPS 15836-18882
7) Tapes 53*-69*, SPS 18883-20372

Mainlab Log (original)

Seismic Recording Log (original)

2 DOS Floppy disks containing EW9608 MCS recording and gun logs . Four files for line 1a:
*.RUL (recording log), *.RUE (recording error log), *.TAL (gun log), and *.TAE (gun error log).

MacIntosh floppy disk(s) of Main Lab Mac EW9608 cruise report files, MCS log, etc.

2 sets of 8mm EW9608 Underway Geophysics tape(s) (Mag, Bathy - Hydrosweep centerbeam, Nav, Grav)
St. John's, NFLD - St. George's, Bermuda

General Location of On-Line Cruise-Related Data

OBH data location summary

Experiment	*.raw files	*.segy files (segydir)
MARBE1	jade0	jade0, indigo1 (after 11/5)
MARBE2	jade1	jade1
MARBE3	indigo3, indigo4	indigo4
MARBE4	alpamayo0	alpamayo0
MARBE5	jade0, jade1	indigo0
MARBE6	alpamayo0	indigo2

obh* subdirectories contain *.raw files from offld6 program, *.hdrs files from obh_rec_hdrs program, preliminary and final *.rec and *.par files for running obh_to_segy.

segydir/obh* subdirectories contain segy output files from obh_to_segy program, processing scripts, pltsegy parameter files, pltsegy record section plots, and ww picks

obh_locate subdirectories contain matlab scripts, OBH_locations files, obsloc.dat, obsloc.sum, obsloc.out

obh_locate/src subdirectories contain obsloc source and executable code

ORB* subdirectories contain refdump o/p, ref2log o/p, ref2segy o/p, log files, error files, segy files

jade: - OBH data processing, ORB data processing, PASSCAL processing software
jade0/bullseye
marbe1/obh*
marbe1/segydir (before 11/5)
marbe1/segydir/Pick_mar - matlab scripts for picking and display, output files from picking
marbe2/ORB2 - ORB2 test
marbe2/ORB2/test2 - ORB2 test2 *.ref, *.log, segy files

marbe2/ORB2/test3 - ORB2 test3 *.ref, *.log, segy files
marbe5/obh*
jade1/bullseye
marbe2/obh*
marbe2/segydir
marbe5/obh*
obh_locate
obh_locate/src
jade2/bullseye
jh - John Hallinan's ORB test data
marbe1/ORB2
marbe2/ORB1
marbe3/ORB*
marbe5/ORB*
marbe6/ORB*
ORB_test
ORB2_test
indigo: - OBH data processing
indigo0/bullseye
marbe* - all OBH predeployment and postrecovery log files and WHOOPS data files
marbe5/segydir/obh*
marbe5/segydri/obh_locate
indigo1/bullseye
marbe1/segydir/obh* (after 11/5)
marbe1/segydir/Pick_mar - matlab scripts for picking and display, output files from picking,
RUNS summary of pick processing
marbe1/segydir/Pick_mar/src - segy2mat, segy2mat2
test01/obh22 - OBH 22 / ORB 2 test deployment data
indigo2/bullseye
marbe6/segydir/obh*
indigo3/bullseye
marbe3/obh*
indigo4/bullseye
marbe3/obh*
marbe3/segydir/obh*
obh_locate - marbe3 data
obh_locate/src
alpamayo: - OBH data processing, obh_to_segy development, GMT plots, Ewing MCS logs
alpamayo/allegra/data/allegra/mar - figs, grav, grids, obh, topo subdirectories
alpamayo0/bullseye
marbe4/obh*
marbe4/segydir/obh*
marbe5/ORB1
marbe6/obh*
mcslogs - recording and gun logs from MCS line 1a
ORB_tape_test
obh_locate - marbe4 data
obh_locate/src
test01/obh22
test01/segydir/obh22
skellig: - ORB processing software development and testing, PASSCAL processing software
orizaba: - MCS processing
thielsen: - OBH arrival picking, OBH relocation
mazama: - OBH arrival picking, OBH relocation
heezen: - mbsystem processing package: XBT data processing; Hydrosweep multibeam data processing, editing, gridding
hess: - underway geophysics data files
/net/hess/science/data

Appendix 21

Science Complement And Crew List

Science Complement

Robert S. Detrick	Chief Scientist	WHOI
John Collins	Co-PI	WHOI
Graham Kent	Co-PI	SIO/IGPP
Jian Lin	Co-PI	WHOI
Douglas Toomey	Co-PI	U Oregon
Joe Stennett	Science Officer	L-DEO
Carlos Alverez	Airgun tech	L-DEO
John Bailey	Engr. Asst. III	WHOI
Andrew Barclay	Graduate Student	U Orgeon
Stef. Budhypramono	Computer Sys. Mgr.	L-DEO
John DiBernardo	Pneumatic Engr.	L-DEO
James Dolan	Res. Associate	WHOI
Charles Donaldson	Electronic Tech	L-DEO
David DuBois	Sr. Res. Assistant	WHOI
Carlos Guterriez	Airgun tech	L-DEO
John Hallinan	Res. Engineer	WHOI
Emilie Hooft	Graduate Student	MIT/WHOI
Allegra Hosford	Graduate Student	MIT/WHOI
Stefan Hussenoeder	Graduate Student	MIT/WHOI
Ropate Maiwiriwiri	Airgun Tech	L-DEO
F. Beecher Wooding	Res. Associate	WHOI

Crew List

Ian Young	Master
Louis Mello	Chief Mate
William Smith	2nd Mate
Richard Thomas	3rd Mate
John Santini	Boatswain
John Patch	A/B
David Wolford	A/B
Ellen Ochtman	A/B
Robert Hagg	O/S
George Mardones	O/S
Stephen Pica	Chief Engr.
Matthew Tucke	First Engr.
Richard Reid	2nd Engr.
William Osborn	3rd Engr.
Michael Spruill	Oiler
Guillermo Uribe	Oiler
Edward Shimel	Oiler
Francisco Matos	Electrician
Andrew Blythe	Steward
John Smith	Cook
Luke Moqo	Utility
Pete Martin	Radio Operator