

Carbottle



ARAD 3D



**Anatomy of a Ridge Axis Discontinuity (ARAD)  
3-D Seismic Experiment**

**Cruise Report  
EW-9707  
R/V Maurice Ewing  
Panama City, Panama to Manzanillo, Mexico  
September 8 — October 25 1997**

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## Summary

R/V *Maurice Ewing* leg 97-07 successfully carried out the first 3-D reflection/tomographic survey of a mid-ocean ridge at the proto-typical 9°03'N Overlapping Spreading Center (OSC), East Pacific Rise. The ARAD (Anatomy of a Ridge-Axis Discontinuity) 3-D Seismic Experiment was acquired to test competing models of magmatic segmentation beneath fast spreading centers; the resultant 3-D images of reflectivity and velocity should help distinguish between models of segmentation along fast spreading centers which view large, non-transform discontinuities as sites of either enhanced or diminished magmatic activity.

The 3-D reflection field program was conducted using a highly tuned 10-gun 3050 cu. in. (50 l) source array. The airgun array was floated at ~8 m depth to ensure consistency of waveforms throughout the survey. The source signatures were also recorded on Lcheapo *Godzilla*, which was anchored ~1 km above the seafloor to avoid interference from bottom reflections. The *Ewing's* 3100-m-long (124 channel, 25 m group spacing) Digicon DMS-2000 streamer was towed at ~12 m depth, and deployed throughout the entire experiment. Shipboard navigation was achieved through an INMARSAT-based differential GPS system supplied by *John E. Chance & Associates* which was accurate to within a few meters. Streamer positioning was reconstructed using bearing measurements (few tenths of a degree accuracy) from 12 *Digicourse* compass birds placed at 250 m intervals along the streamer; streamer positioning was checked against occasional radar and GPS fixes from the PGS tailbuoy, which confirmed our streamer solution with along- and cross-track errors no greater than 10-20 m and 10-30 m, respectively—error bounds that are well within our desired binning scheme of 25 m in-line by 100 m cross-line. In total, 209 sail lines were collected—201 original, 8 repeat—at 100 m interval along-strike; these data will be used to create a 13+ million trace, 20 km by 20 km reflectivity volume.

The 158,000+ shots fired during 5 weeks of continuous "MCS" acquisition, plus an additional 2000+ temporally less-frequent "OBS" shots (to record far-offset arrivals such as Pn & PmP), were also recorded by a Scripps/Cambridge on-bottom array of 14 Scripps Lcheapo hydrophones, 11 Cambridge mini-DOBS hydrophones, and 5 Cambridge developmental 4-component seismometers; these instruments were placed in a somewhat regular grid across the overlapper with 3-10 km instrument spacing. 29 of the original 30 instruments were recovered (one Cambridge mini-DOBS was lost during deployment due to a low-pressure leak); of these instruments, 11 of 15 Cambridge mini-DOBS recorded useful data, while all 14 Scripps Lcheapos recorded throughout the duration of the experiment. In total, some 1-2 million travel picks will be available for tomographic and modeling purposes, including the generation of the "first" OBH/S record volume.

The ARAD 3-D Seismic Experiment is an international collaborative project between investigators at the Scripps Institution of Oceanography and the University of Cambridge, with financial support from the RIDGE program/National Science Foundation (U.S.), British Institutions Reflection Profiling Syndicate (BIRPS), and the Natural Environment Research Council (U.K.). Additional matching funds for computer visualization were provided by Scripps Institution of Oceanography. The cost of seismic data acquisition, differential GPS, and navigation reduction was shared equally between U.S. and U.K. funding agencies.



## 1.0 Science Primer

Early investigation into the geometry of mid-ocean plate boundaries was based on widely spaced profiles of limited resolution which led to an idealized picture of mid-ocean ridges as linear features occasionally offset by large transform boundaries. The advent of high-resolution swath mapping in the late seventies, however, provided dramatic images of ridge-axis structure indicating a highly complex system which was segmented on a variety of scales. Multibeam images measured significant variation in axial depth, and uncovered a rich diversity of plate boundary structures including propagating rifts, overlapping spreading centers (OSCs), and deviations in axial linearity. The larger of these ridge-axis discontinuities were usually sited along deeper portions of the ridge crest, and were associated with regions of disturbed off-axis topography in the form of "wakes" suggesting that these features were not static, but migrated along the axis of spreading, shortening and lengthening the adjoining segments.

Petrologic sampling along mid-ocean ridges revealed similar patterns of geochemical segmentation (*Langmuir et al.*, 1986) suggesting an intimate connection between tectonic and magmatic segmentation of the ridge-crest. Many models of magmatic segmentation propose enhanced upwelling beneath the shallowest portions of the ridge crest, and, by inference, places OSCs along magmatically starved sections of the ridge (e.g. *Macdonald et al.*, 1984), although there are models suggesting the opposite (*Lonsdale*, 1983). Other indicators of magma budget such as axial volume (*Scheirer and Macdonald*, 1993) and mantle Bouguer anomaly (*Magde et al.*, 1995) tend to support the notion that shallower, more inflated ridges, are sites of magma injection from the mantle, which serve as the locus for redistribution of melt toward the distal ends of the segment. Seismic data from the northern East Pacific Rise (*Kent et al.*, 1993) and Valu Fa Ridge (*Collier and Sinha*, 1992) suggest a complex relationship between ridge-axis discontinuities and the underlying pattern of magmatic segmentation; reflection images from these two locales show an increase in melt sill width toward two large OSCs. The robust nature of the 9°03'N OSC is further supported by an increase in travel time "thickness" of both layer 2A (*Harding et al.*, 1993) and Moho (*Barth and Mutter*, 1996) reflections, although *Wang et al.* (1996) argue that the observed increase in crustal thickness toward the OSC can be explained through efficient along axis transport of melt away from the localized center of upwelling at 9°50'N.

Quantifying melt distribution and crustal structure across ridge-axis discontinuities is essential for understanding the relationship between magmatic and tectonic segmentation of spreading centers; the geometry and continuity of melt across these features can have a profound effect on the composition of erupted lavas, and may give insights into the underlying pattern of mantle flow. Previous multichannel seismic (MCS) surveys of ridge axes have been reconnaissance in nature with an along-strike spacing of kilometers at best—sometimes 10 km or more. Moreover, widely-spaced profiles are susceptible to out-of-plane contamination or "side-swipe", which can result in significant imaging errors in the presence of 3-D structure. To test competing models of magmatic segmentation, we have conducted the first 3-D seismic reflection and tomographic survey of a mid-ocean spreading center at the proto-typical 9°03'N OSC, East Pacific Rise. The combined 3-D seismic experiment will bring an unprecedented level of detail to seismic images of the oceanic crust. Just as the increased resolution of swath bathymetry provided new insight into the dynamics of the mid-ocean ridge system, we believe that these 3-D images will provide significant insights into the interplay between magmatic and tectonic segmentation along the East Pacific Rise.



The completed survey should accomplish a host of scientific objectives including:

- 3-D mapping of magma chamber structure across a large non-transform offset (NTO) to determine melt sill morphology and connectivity.
- 3-D mapping of velocity structure across discontinuity through innovative tomographic and prestack depth migration techniques.
- 3-D mapping of seismic layer 2A thickness to investigate variations in upper crustal structure across the offset, and to understand better the nature of the 2A/2B boundary.
- 3-D mapping of Moho structure to ascertain lower crustal continuity, and determine the nature of Moho transition beneath the ridge axis.
- 3-D mapping of the physical properties of the melt sill through waveform and amplitude variation with offset (AVO) analyses.

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## 2.0 Operational Objectives

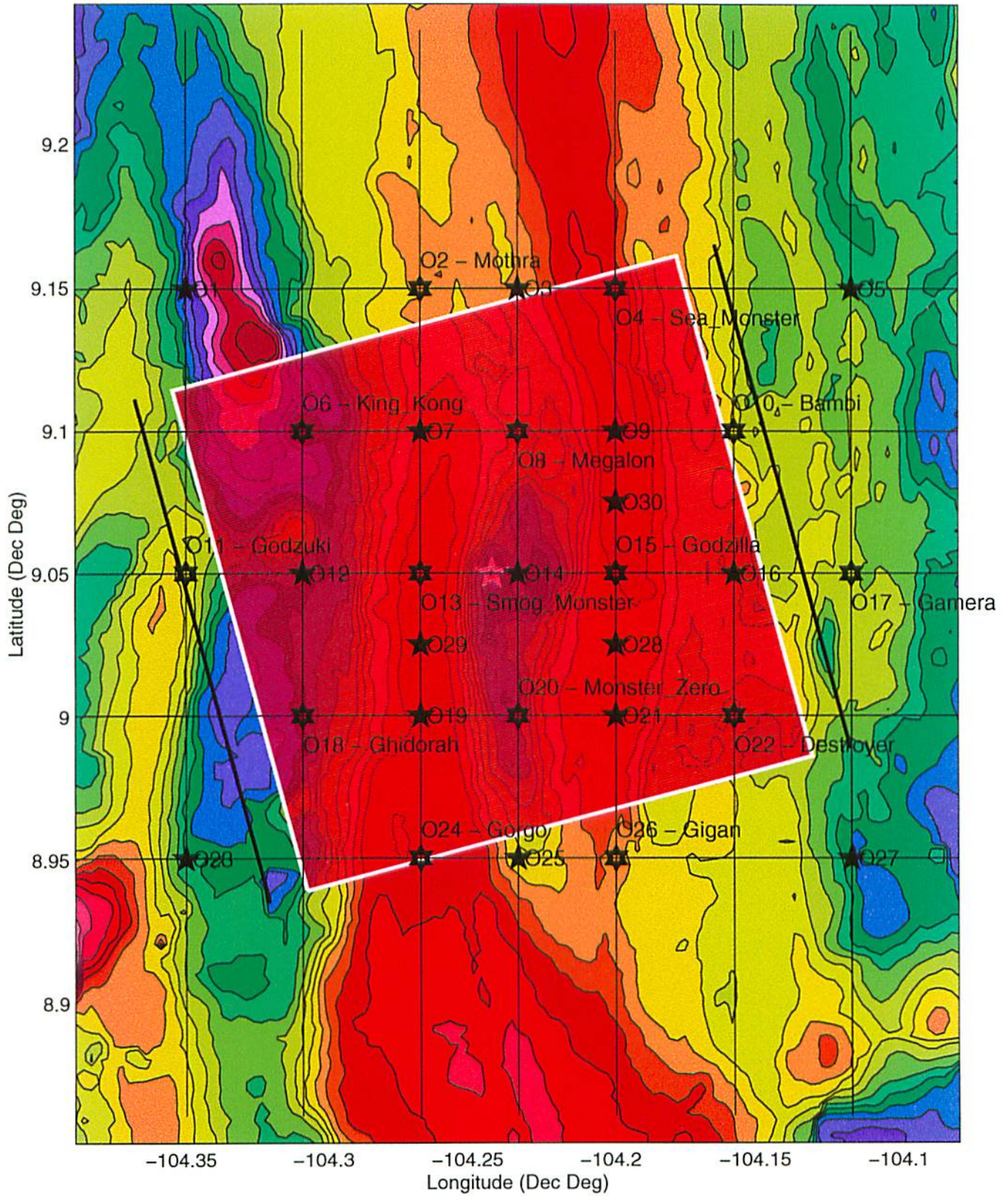
The ARAD 3-D Seismic Experiment consisted of 201 "sail" lines (23-km-long each) separated by 100 m along-strike (plus 8 profiles were reshot to enhance coverage); in addition, 11 OBS profiles were shot at 110 s (~250 m) intervals along (7 lines) and across (4 1/2 lines) the OSC in a pattern designed to delimit the shape of the underlying low-velocity zone, and to constrain any variation in crustal thickness near the overlapper. The dimensions of the on-bottom array of 30 instruments extend ~22 km along-strike by ~25 km cross-strike, with an instrument spacing which varied between ~3 km to ~10 km. The experimental layout of the ARAD 3-D cruise is seen on the following page.

### The primary operational goals of this leg included:

- Deployment of the 30 instrument on-bottom array.
- Acquisition of 201+ sail lines, separated by 100 m along-strike.
- Real-time monitoring of streamer feathering/reconstruction, including DGPS and compass bearing measurements.
- Verify compass solution with fixes to tail buoy.
- Real-time 2-D stacks of MCS data, including generation of seismic "flip-book".
- Tape copy from 3480 SEG-D tapes to DAT/Exabyte SEG-Y format.
- Reshoot regions of sparse coverage as determined from real-time processing.
- Recovery of the 30 instrument on-bottom array.
- Test "work boat" recovery scheme for dense on-bottom instrument array.
- Operational test and evaluation of 24-bit SCAM Lcheapo.



## ARAD 3-D MCS and OBS Experiment





### 3.0 Cruise Narrative

Friday, Sept. 5th (JD 248) - Sinha, Singh, Owen, Boschi, Cherrett, Tong, Greer, and Zimmer meet the *Ewing* in Cristobol/Colon; Cambridge OBS van is loaded aboard the ship, while SIO container is emptied into the outer lab. *Ewing* sails through the Panama Canal during night time with the Cambridge crew aboard; Zimmer returns to Panama City to meet the Scripps contingent. Kent, Harding, Hollinshead, and Van Avendonk arrive in Panama City mid-day, followed by Henkart and Hussenoder who arrive at night. Lastly, Mike Mullarkey (John E. Chance) arrives shortly after 8 PM which completes the list of those who need to arrive.

Saturday, Sept. 6th (JD 249) - Scripps group meets the *Ewing* at Noon. Both groups begin to unpack and setup ocean bottom instrument labs; the Scripps' group use the Dry Staging Room for instrument preparation, while the Cambridge group makes a home within the CTD Room (aka Ping-Pong Room). Simultaneously, computers are unpacked and configured giving the ship the feel of a *Unix* sweat-shop. Computers boot nicely, and are in working order by day's end. John E. Chance DGPS equipment is connected to the Inmarsat, and ship's position is logged at the pier, both in differential & normal modes.

Sunday, Sept. 7th (JD 250) - After 12 hours of logging DGPS, variations in ship position from the differential signal showed excursions of less than 3 m, while non-differential GPS varied position by no more than 60 m. DGPS corrections sent by Inmarsat showed about 15 s worth of dropout, every 4-5 hours, although this may have been a function of the local environment which was very near a U.S. Army base. More alarming was the realization of a possible problem due to blockage of the Inmarsat satellite by the upper-wing of the *Ewing* mast on E-W lines. Some thought was given to moving the unit, or flying in a rental unit, but it was decided to continue onto the station, and either shear the grid to alleviate blockage, or possibly shoot the E-W lines with less accuracy, at least immediately, and correcting positions at a later time via corrections from remote GPS base station, thereby allowing the desired accuracy of positioning. It was also realized that the Scripps' 3490 tape drive was not working correctly, and was disassembled by Crispin Hollinshead, but nothing was found out of the ordinary. Paul Henkart mailed Overland to investigate the problem further. If the unit can not be brought back to life, the SIO group will use the 3480 unit on the Sparc Station *hess*, while inconvenient, is certainly a workable solution. The Cambridge group's spare Exabyte showed some problems as well, but seems to be in working order now.

Monday, Sept. 8th (JD 251) - Scientists and crew settle in for the long haul...*Ewing* leaves the pier at 12 Noon, making about 11 knots, which should bring us to the field area on Saturday night, September 13th, at roughly Midnight. A strategy for on-bottom instrument deployment and location between the groups is worked out, along with a tentative launch schedule. Cambridge and Scripps will alternate the first four launches, and after acoustics have been checked-out for the 4 different types of instruments, we'll go into roughly 8 hours shifts between different groups until the entire array has been laid out. Both groups continue to check out their respective instruments, so far without in major problems. Kent, Harding, Singh and Sinha discuss navigation of the ship relative to track-lines; it is decided that 10 m either side of the line is not problematic, while the zone between 10-20 m should require action aboard the Bridge, with any long term deviation beyond 20 m not acceptable.

Tuesday, Sept. 9th (JD 252) - Harding & Kent visit with the Captain to discuss navigation; our plan from the previous night seemed to be reasonable given the capabilities of their auto-pilot running in a "tracking" mode. Other aspects of navigation including turning radius were discussed. The Captain & Johnny DiBernardo both thought that somewhere



between 5°/minute & 10°/minute were possible. Science meeting was held at 14:00 local in the Lounge.

Wednesday, Sept. 10th (JD 253) - Streamer party amassed on the deck at 10:00 local to flake 6 streamer sections (600 m) onto smaller spools anticipating the need for 3100-3200 m worth of offset for the MCS survey. Presently, 3400 m of streamer remain in the spool, including a few leaking sections which will be taken out during deployment. On the OBS/H front, both groups are continuing to checkout instruments, glass sphere & acoustics with the Scripps' group about half-way through final checkout, while the Cambridge group will likely power their instruments up tomorrow. Inmarsat signal remains fairly strong (40-50), even though our course is running at 275°, which places the satellite aft of the *Ewing* mast.

Thursday, Sept. 11 (JD 254) - Both instrument groups continue progress on equipment checkout. Inmarsat signal seemed to be quite strong throughout the day, giving more hope that the original grid could be shot without rotation. Graham & Vincent enjoy their 35th and 22nd birthdays, respectively. Andy and Lynne (*Ewing* cooks) bake two separate birthday cakes, one candle each, thankfully. Local currents impede our progress, with speeds of below 10.8 knots during the evening hours.

Friday, Sept. 12 (JD 255) - Currents are now running E-W, with the *Ewing* cutting through the seas at 13+ knots. Also a southerly swell has picked up, rocking the ship up to 10-15°. Either progress West, or the ship's yaw, or both, has caused the DGPS to become somewhat flaky, especially around Noon. Dropouts last only a few ten's of seconds, with a few minutes of coverage, before another break in transmission. By evening's end, Inmarsat has rebounded again and is quite strong, and the scientific party is hopeful. 14 "L Cheapos" have been checked out, ready for launch Sunday morning. By dinner-time, the Cambridge group has 10 of their 16th instruments ready for launch. Seas have settled a bit as well. We are able to get the DDS2 DAT running on SparcStation *hess*, which will again allow two separate tape copies, still no word from Overland.

Saturday, Sept. 13 (JD 256) - Instrumentation groups finalize launch schedule. Inmarsat, and subsequently DGPS, grows weaker and weaker on the 270° bearing, due to the port-side obstruction of the radar platform "wing" as anticipated. Course changes between 255°, 260°, 265° and 270° were performed twice during the day to test ship course sensitivity to Inmarsat blockage. It was found that a course of 255° produced a useable signal, while 260° was good only during calm seas, while 265° and 270° were unusable. The greater the sea state, the more abrupt was the loss of signal. It was decided that the 3-D reflection grid could be rotated no more than 15° toward 255°, which still placed DGPS reception on the razor's edge in terms of robustness, given variation in local currents and sea state. Lastly, more tests were performed on the Overland 3480, with no luck—still in the Sparc Station tape copy mode.

Sunday, Sept. 14 (JD 257) - Cambridge group first launches their two different instrument types to test acoustic reception; instruments were followed to seafloor, no problems were encountered. Likewise, Scripps group launched both EM- and seismic-styled L-Cheapos, both instruments performed flawlessly, at least acoustically, and were placed in a disabled acoustic state. Chief Scientist talks with Captain regarding modifications to the radar platform; also an email was sent to Mike Rawson back at LDEO regarding the DGPS problem. SIO group launches next 5 instruments, and then circles back to disable each of the 5 remaining L Cheapos, no problems were encountered. Following a shift change, the Cambridge group follows by launching the next 7 instruments, with only one problem encountered, an OBH (site O21) was lost acoustically within seconds after loss, which may have been caused by shallow-level flooding. Toward day's end, Scripps group launches final 7 L Cheapos into the next morning.....



Monday, Sept. 15th (JD 258) - The 14th L Cheapo was launched around breakfast time, followed by another circuit to disable the remaining 7 L Cheapo instruments which went off without a hitch. Cambridge group launches remaining 7 instruments without any problems, finishing the job around 5 PM local, right on schedule. Tail buoy is launched shortly thereafter, but GPS fails immediately, tail buoy is then recovered, problem is fixed. Tail buoy is then re-launched, GPS fails this time after 300-400 m of deployment. It is decided to continue to launch the streamer, and use the Zodiac when seas abate, to try to fix the problem while underway. Streamer continues to be paid out, Digicourse Lease Birds seem to be interfacing with out problems. Launch continues.....

Tuesday, Sept. 16th (JD 259) - Streamer is finally launched in the wee early hours of the morning, but the tail section is riding below 30m — clearly it will be redeployed before reflection profiling starts in earnest. It is decided to deploy the guns and shoot an OBH line or two before recovering the streamer, which will also allow inspection of the reflection data (low-fold) to determine whether any bad sections exist. After shooting OBH line L, it appears that traces 45, 74, 87, 99, 113, 115, 116 are bad. Ship heads to the eastern waypoint for line N, while streamer recovery operation starts. After recovery of the streamer and tail buoy in the late afternoon, some additional OBH shooting occurred during tail buoy inspection (Line MN'). Streamer reblancing and deployment begins after supper, and continues into the morning with cans and/or streamer sections replaced which brought the number of bad channels to 1.

Wednesday, Sept. 17th (JD 260) - Shooting line N begins shortly thereafter, followed by Line P. Seas appear unfavorable (DGPS-wise) to our 255° skewed grid, which will likely result in the removal of the port-side radar deck. Weather continues to be choppy, even through tropical storm Nora moves northward, approximately 300 nm from our site.

Thursday, Sept. 18th (JD 261) - Continue shooting OBH Lines K, J, I and F. Weather continues to be poor, with gusts upwards of 20-30 knots. Tropical storm Nora is still stationary some 300 miles to the North, just off shore of Manzanillo, Mexico. By day's end, shot interval changes from 110 s to 37.5 m (~ 15-16 s), which ushers in our first MCS profile, Line 201.

Friday, Sept. 19th (JD 262) - MCS shooting begins in earnest; profiles were laced northward within the MCS box, with a profile spacing of 33 lines. MCS profiles 201, 168, 135, 102, 69, and 36 were shot from South to North. Some problems were encountered during the turns, an extra bit of lead-in was needed to negotiate the 5° per minute turn, but navigation along-track using the ship's auto-pilot was excellent, especially given the sea state which was poor, thanks to Hurricane Nora. The high sea-state produces an upward pull on the streamer, which sends "waves" down the cable, bringing portions to or near the surface, giving poor signal to noise ratios for those shallowest sections. In light of the current weather conditions, it was decided to break off MCS shooting, and attempt to finish the OBH survey, or nearly, to take "advantage" of the rough seas, and not collect MCS data, for now, in hopes of better weather in 24 hours.

Saturday, Sept. 20th (JD 263) - Finished MCS line 3. Shot OBH Lines M, A, B, and C at 110 s rep. rate, 1000 ms randomization. Weather continues to abate, wind speed drops below 20 mph, sea-state improves, although is still somewhat rough. Shortly after dinner, during the turn from OBH Line B and C, the streamer is pulled to place two additional birds on the cable head to add weight, and give more depth control on the front section, thereby reducing the "floating" previously seen within the first 4-6 sections. This small measure seems to be working, with the streamer flying near the specified 12 m water depth.



Sunday, Sept. 21st (JD 264) - Switching into MCS mode once again, shot MCS Lines 199, 166, 133, 100, and 67. Seas continue to settle, but not fast enough. Data quality is vastly improved when compared to the 7 lines shot two days previously. Hurricane Nora quickens its departure at nearly 10 knots to the NW.

Monday, Sept. 22 (JD 265) - Shot MCS lines: 34, 1, 32, 5, 38, 7, and 40. Encountering the double-tape eject problem; watch-standards oversee each tape change, ensuring that an additional tape is ready ASAP. Usually results in the loss of 3-6 shots, and is occurring a few times daily!

Tuesday, Sept. 23 (JD 266) - Shot MCS lines: 40, 9, 42, 11, 44, 13, 46, and 15.

Wednesday, Sept. 24 (JD 267) - Shot MCS lines: 48, 17, 50, 19, 52, 21, and 54.

Thursday, Sept. 25 (JD 268) - Shot MCS lines: 23, 56, 25, 58, 27, 62 and 29.

Friday, Sept. 26 (JD 269) - Shot MCS lines: 60, 31, 64, 33, 66, 35, and 2. Reversing the "zamboni", continue to shoot.

Saturday, Sept. 27 (JD 270) - Shot MCS lines: 37, 4, 39, 6, 41, 8, 43.

Sunday, Sept. 28 (JD 271) - Shot MCS lines: 10, 45, 12, 47, 14, 49, and 16.

Monday, Sept. 29 (JD 272) - Shot MCS lines: 51, 18, 53, 20, 55, 22, and 57.

Tuesday, Sept. 30 (JD 273) - Shot MCS lines: 24, 59, 26, 61, 28, 63, and 30.

Wednesday, Oct. 1 (JD 274) - Shot MCS lines: 65, 88, 71, 90, 73, 92, 75, and 94. Reversing the "zamboni" once again. Had to abort western third of line 90 due to obstruction by tuna boat.

Thursday, Oct. 2 (JD 275) - Shot MCS lines: 77, 96, 79, 98, 81, 104, 83, and 106.

Friday, Oct. 3 (JD 276) - Shot MCS lines: 85, 108, 87, 110, 89, 68, and 91. Reversing the "zamboni"—will this ever stop!

Saturday, Oct. 4 (JD 277) - Shot MCS lines: 70, 93, 72, 95, 74, 97, and 76.

Sunday, Oct. 5 (JD 278) - Shot MCS lines: 99, 78, 101, 80, 103, 82 and 105.

Monday, Oct. 6 (JD 279) - Shot MCS lines: 84, 107, 86, 109, 132, 111, 134, and 113. New "zamboni".

Tuesday, Oct. 7 (JD 280) - Shot MCS lines: 136, 115, 138, 117, 140, and 119. Line 115 reshot due to gun failure.

Wednesday, Oct. 8 (JD 281) - Shot MCS lines: 142, 121, 144, 123, 146, and 125.

Thursday, Oct. 9 (JD 282) - Shot MCS lines: 148, 127, 150, 129, 152, 131, and 112. Noticed problem w/ digitizer at shot# 103970-111,197—intermittent thereafter. Every other sample is good, significant bit is lost on other sample—do not filter before resampling. We decide to push forward.



Friday, Oct. 10 (JD 283) - Shot MCS lines: 137, 114, 139, 116, 141, and 118. Reshot profile 139 due to gun failure.

Saturday, Oct. 11 (JD 284) - Shot MCS lines: 143, 120, 145, 122, 147, 124, and 149.

Sunday, Oct. 12 (JD 285) - Shot MCS lines: 126, 151, 128, 153, 130, 155, and 180. New "zamboni".

Monday, Oct. 13 (JD 286) - Shot MCS lines: 157, 182, 159, 184, 161, 186, and 163.

Tuesday, Oct. 14 (JD 287) - Shot MCS lines: 188, 165, 190, 167, 192, and 169. Aborted first attempt to shoot 192 due to gun failure. Kent, Singh and 2nd Mate run rescue boat along side tail buoy to help calibrate (w/ GPS) compass bird measurements. Similar GPS unit is logging data back aboard the *Ewing*.

Wednesday, Oct. 15 (JD 288) - Shot MCS lines: 194, 171, 196, 173, 198, 175, and 200.

Thursday, Oct. 16 (JD 289) - Shot MCS lines: 177, 154, 179, 156, 181, 158, and 183. Reversing "zamboni".

Friday, Oct. 17 (JD 290) - Shot MCS lines: 160, 185, 162, 187, 164, 189, and 170.

Saturday, Oct. 18 (JD 291) - Shot MCS lines: 191, 172, 193, 174, 195, 176, and 197.

Sunday, Oct. 19 (JD 292) - Shot MCS lines: 178, 2124, 2091, 2130, 2096, and 2071. We decided to reshoot lines 27, 71, 91, 96, 114, 124, 130 and 149 due to poor coverage; aborted any recon shooting toward the Siqueiros.

Monday, Oct. 20 (JD 293) - Shot MCS lines: 2027, 2114, 2149 and Omega. Omega profile is shot for navigational purposes—AMC reflector is visible. Streamer recovered without incident, although appears to be covered with Zebra mussels. A few leaky sections near the ship are removed. One compass bird was lost sometime during the previous month. Recovered Cambridge OBSs 30 and 31. CAMB 31 was recovered successfully, but battery sphere was flooded. SIO instrument Gamera recovered.

Tuesday, Oct. 21 (JD 294) - SIO instruments Bambi, Sea Monster, Godzilla, Smog Monster, Monster Zero, Godzuki, Ghidorah, and Destroyer were recovered. Used workboat with Harding, Zimmer and 2nd Mate to recover instruments in tandem. 4 instruments were recovered in this mode. Cambridge instruments OBS 26, 27, 29, 33, 34, 35, 38 were recovered. CAMB 32 did not respond (contact was lost during decent), and ultimately considered lost.

Wednesday, Oct. 22 (JD 295) - SIO instruments Gigan, Gorgo, King Kong, Megalon and Mothra were recovered. All 14 SIO instruments apparently recorded during the entire duration of the experiment, with 100% data recovery. Cambridge instruments: 28, 36, 37, 39, 40, 41 were recovered. It appears that 11 of the 16 Cambridge instruments worked throughout the experiment, with the most heavy loss toward the eastern edge of the 3-D box. Nonetheless, wide-angle coverage is more than adequate for our purposes. 29 instruments were recovered in roughly 48 hours—go team!

Wednesday, Oct. 22 (JD 295) - Redeployed CAM OBS 36 and SIO 24-bit prototype Sir Charles for an engineering test. A short, off-axis N-S profile was shot using a modest (~1000 cu. in.) 2-gun array. Instruments were then recovered—heading for Manzanillo.



Thursday, Oct. 23 (JD 296) - Heading home, both groups begin to pack their gear up!

Friday, Oct. 24 (JD 297) - Heading home, both groups finish packing their gear up, land ho manana. Final pull-up contest, 21 remains the high mark (Kent), Zimmer finishes with 20.

Saturday, Oct. 25 (JD 298) - Arrive in Manzanillo, Mexico in time for dinner, Que Bueno! Some problems arise in regards to shipping the Cambridge container; clearly some miscommunication between Lamont and shipping agent— and in Latin America, that can be costly \$\$\$\$. Because of these difficulties, the SIO contingent is first to consume the local brew. The Cambridge group follow shortly thereafter. A joint U.S.-U.K. versus Mexico basketball match (thanks Anthony), results in some major ass-whoopin, scoreboard Mexico. Marlins win the World Series, true! Hang-overs abound!!!



## 4.0 Navigation

### ARAD Coordinate Systems

The ARAD experiment and analysis makes use of the following sets of coordinate systems -

1. Lat/Lon from differential GPS. GPS positions are specified in terms of the WGS84 reference ellipsoid.
2. A local, UTM based, Cartesian frame. This frame is based on a UTM transformation with a reference longitude of  $-104.25$  ( $104^{\circ} 15'$  W) which approximately coincides with the east side of the western limb of the OSC. The corresponding fractional UTM zone number is 13.125.
3. Box metric coordinates. This is a cartesian coordinate system for the ARAD 3-D MCS 20x20 km imaging box. This is a left handed system with origin in the bottom left hand, ~SW, corner. The transformation from local UTM,  $x$ , to box coordinates,  $b$ , is given by
$$b = R (x - x_o)$$
where  $x_o = (493687.437, 988143.87)$  and  $R$  is a  $15^{\circ}$  clockwise rotation. The lat/lon of the origin is  $(-104.307420, 8.939218)$ .
4. Sail line coordinates. The individual sail lines of the ARAD experiment. In this coordinate system, the waypoints marking the end of individual sail lines of are numbered from North to South, with sail line 1 framing the northern edge of image box, and sail line 201 framing the southern edge.

This non standard zone was chosen so that as closely as possible lines of latitude correspond to lines of constant  $y$  and lines of longitude to lines of constant  $x$ .



# Navigation & Underway Geophysical Data

## Introduction

The R/V Ewing has essentially two forms of underway geophysical data files, the raw data files captured by the real time system - "moray" and processed navigation files which are the same data merged with the navigation after perhaps editing, filtering, and resampling to a fixed time interval. The processed files are created from the raw data files at the end of each day and are given to the P.I.s together with a data reduction summary at the end of the cruise. The processed files are usually the primary source for subsequent data analyses. However, when the raw and processed navigation files were compared for the ARAD experiment, a systematic offset of 10-30 m was found in the ship location. Subsequent investigation revealed that this offset was due to an error in way the Ewing navigation code interpolated ships positions whenever more than 2 ship locations were recorded in a given 30 second interval. Since this systematic error was at least 2-3 times larger than the expected error in the DGPS positions, all navigation data relating to seismic acquisition were recomputed from the raw data files prior to subsequent processing.

The following sections discuss the naming conventions for the Ewing underway geophysical data, the source of the original navigation error, and the subsequent reprocessing of the navigation and seismic acquisition data.

## Naming Conventions

The R/V Ewing organizes the underway geophysical data by type and by Julian day. The raw geophysical data are named according to the following convention

<Cruise I.D.><data\_type>.d<julian\_day> e.g. 9707gp1.d270

The Ewing cruise I.D. for ARAD was 9707. The various data types recorded during ARAD include

|       |   |
|-------|---|
| cb1   | compass bird data                                   |
| ct    | sea surface temperature                             |
| dg    | gun depths  |
| fu    | Furuno speed and heading data and gyro heading data |
| gp1   | Trimble NT200D GPS navigation data                  |
| gp02  | STARFIX-MN8 GPS navigation data (from John Chance)  |
| gp3/4 | Magnavox MX-4200 GPS data                           |
| hb    | Hydrosweep centerbeam depths                        |
| hs    | Full Hydrosweep data                                |
| tr1   | True time clock                                     |
| ts2   | Shot time data                                      |
| wx    | Weather station data                                |

The raw data files from ARAD are archived at Scripps in the directory /net/archive/optical/mcs/arad/moray.

The naming convention for the Ewing processed files is

<data\_type>.n<julian\_day> e.g. ts.n270

## Ewing Navigation Processing Sequence

The Ewing post processing of underway data combines two data streams - a GPS/navigation stream and a data edit stream to form a merged processed output. The GPS part of the navigation stream consists of the following stages

1. Reformat the raw GPS files to a common format (program fmt\_trimble)



2. Resample the GPS data to fixed 30 second intervals on the minute and half minute using linear interpolation.
3. Smoothly interpolate the GPS fixes using a running average window of 5,7,9 or 4 points, corresponding to 2,3,4 or 20 minutes .

The ARAD data was smoothed with a 9 point window, corresponding to a half width of 2 min. The edge effects of this window were noticeable in the navigation data at the beginning/end of each day, and produced an artificial mismatch/jump in shots positions across day boundaries.

The second part of the navigation stream consists of the following stages

1. Merge GPS, transit, and loran fixes (no longer really relevant).
2. Fill in any navigation data gaps larger than 2 minutes using dead reckoning and smoothed Furuno heading.
3. Find and flag unusually large drift values.

The processed navigation is used as an input when processing the other underway data. For example the processing of the shot, ts files involves the following stages:

1. Find and mark the bad/missing shot times
2. Merge shot times with navigation by interpolating processed navigation to shot times
3. Interpolate bad/missing shot times

The source of the systematic navigation error discussed in the introduction arises from stage 2 of the GPS processing, the linear interpolation of the data to fixed 30 second intervals. The problem arises because the code implicitly assumed, in a hold over from the days of transit satellites, that there will not be more one position fix within any 30 second interval. During the ARAD experiment, raw GPS fixes were either recorded approximately every 10 s or every 2 s. When the fixes are more frequent than every 15 s, the effect of the interpolation algorithm can be summarized as follows:

At the previous 30 sec boundary say  $t_0$ , let the interpolated position of the ship be  $ix_0$ .

Let  $\Delta t_1$ ,  $0 \leq \Delta t_1 \leq 15$ , be the elapsed time since  $t_0$  of a GPS fix  $x_1$  at time  $t_1$

Let  $\Delta t_2$ ,  $15 \leq \Delta t_2 \leq 30$ , be the elapsed time since  $t_0$  of a GPS fix  $x_2$  at time  $t_2$

Fixes at  $t_1$  &  $t_2$  are the times of successive GPS fixes that straddle the 15 sec mark, any other fixes are effectively ignored by the program, which tried to forward extrapolate the position to the next 30 second time mark using:

$$ix_{30} = 30/\Delta t_2 * (x_2 - ix_0) + ix_0$$

The code actually implemented:

$$ix_{30} = 30/\Delta t_2 * (x_2 - x_1) + x_1$$

Effectively the original interpolated position had been discarded replaced by  $x_1$ . With fixes  $x_1, x_2$  the linear extrapolation should be:

$$ix_{30} = (30 - \Delta t_1)/\Delta t_{fix} * (x_2 - x_1) + x_1$$

where  $\Delta t_{fix} = (\Delta t_2 - \Delta t_1)$ , is the interval between GPS fixes. The extrapolation factor used in the code,  $30/\Delta t_2$ , based on the initial false position is always less than the required factor and thus the interpolated position will always be behind the actual along track position. The extrapolation factor used  $fu = 30/dt_2$  is always less than the required. The along track error in position, assuming fixes  $x_1$  and  $x_2$  are exact, is

$$\Delta x_{err} = (30 - \Delta t_{fix} - \Delta t_1)\Delta t_1/(\Delta t_{fix}(\Delta t_1 + \Delta t_{fix})) * (x_2 - x_1). \quad 15 - \Delta t_{fix} \leq \Delta t_1 \leq 14$$

$$\text{or} \quad \Delta x_{err} = (30 - \Delta t_{fix} - \Delta t_1)\Delta t_1/(\Delta t_1 + \Delta t_{fix}) * v$$

where  $v$  is the ships speed.

For most of the ARAD MCS experiment, the sail lines were shot at a speed of 5 kts (2.5 m/s) and the time between fixes  $\Delta t_{fix} = 10$  s. With these values the expected along track error varies between 7 & 13 m with an expected value of ~12 m. At 04:26 Z on Jday 290, the interval between GPS fixes,  $\Delta t_{fix}$ , was decreased to 2 s and the expected along track error in position increased to 30 m. Both of these estimates for



the two GPS sampling rates were verified empirically by plotting the raw GPS locations relative to the processed navigation.

## **Recomputation of Navigation Data**

The navigation and selected underway data were recomputed to remove the systematic errors discussed in the previous section. The recomputation was also necessary to eliminate/compensate for the following additional shortcomings of the original datasets

1. The mismatch of consecutive shot locations across day boundaries caused by the edge effect of the navigation smoothing window. Since all Ewing processing is day oriented, the running average (box-car filter) used to smooth the ship locations thereby producing edge effects at the start/end of each day.
2. The locations in the shot files, ts files, are for the GPS antenna and not the air gun array location. A new set of files, sh files, were produced with a correction to the array location.

The recomputation of the GPS navigation followed the procedure used by the Ewing and outlined on the previous page. The raw data was converted to a common format and despiked eliminating any fixes with duplicate or bad time stamps and any pairs of fixes with apparent velocities exceeding 9 kts. Then the fixes were interpolated to a uniform 10 sec sampling and smoothed using a running average with a 2 minute half-width. To avoid problem 1. above, each days GPS fixes were augmented by 1 hours worth of data from the previous and following day before averaging. No attempt was made to do explicit dead reckoning or to distinguish between DGPS and standard GPS. This should be no problem for the main MCS lines of the 3-D experiment where nearly continuous DGPS coverage was recorded. There may be an occasional problem during turns when the blockage of the Inmarsat receiver by the Ewing superstructure caused loss of DGPS for extended periods. However even in these situations which are mostly of interest for the OBH data, the navigation should be no worse than the standard GPS coverage of most cruises and the smoothing should eliminate jumps seen aboard as the system flickered between GPS and DGPS.

*Missing GP02/Starfix data.* Another factor influencing the recomputed positions is that raw GPS data from the more accurate Starfix receiver was not saved for the first few days of the ARAD experiment and is only available from 06:24 Z on Jday 262 which is midway through the first MCS line shot, sail line 201. Whenever possible Starfix data was used in the recomputations, thus all data after day 262 is based exclusively on the Starfix receiver while prior to 262 all data is, by necessity, based on the Trimble navigation. For day 262 there is often files for both Trimble or Starfix receivers, and the files are differentiated by a 1 (Trimble) or 2 (Starfix) appended to the root of the file names. Thus sh1.262 and sh2.262 are the shot files for two receivers and sh.262 is a combined file with data switched at 6:24 Z and between shots 3323/3324. (N.B. There may be a jump in position at this merge if locations in the files for the GPS antenna locations rather than a common reference).

## **Recomputed Files**

The recomputed files are archived at Scripps in subdirectories below the root directory /net/archive/optical/arad/navigation. The new navigation files include

- 1, **nc.d<jday> files replacing n.<jday> files** These are "pure" navigation files giving ship location at one minute intervals throughout each day. For the nc-files all locations are corrected to the Trimble antenna position since this lies directly above the hydrosweep receiver array and the files were used in the compilation of the Hydrosweep bathymetry. (directory nav)
2. **ts.m<jday> files replacing ts.n<jday> files.** These are shot time files following the Ewing standard with locations corresponding to the GPS antenna positions at the shot instance. The shots instances are based on the original Ewing files and the flagging of bad/interpolated shot times is preserved. Thus a bad shot on day 290 has a shot time starting 97-289 rather than the usual 97+290. (directory shots)



3. **New sh.n<jday> files.** These are "true" shot files with locations corresponding to the airgun array positions. The ship orientation for these files was taken from a smoothed version of the recorded gyro heading. Bad shot flagging is preserved. (directory shots)
4. **Updated cb1.n<jday> files.** These are revised compass bird files used for the streamer reconstruction. They were created by combining ts.m<jday> shot location information with the compass bird data. Compared to the original files these have all data drops/data mangling fixed by addition of null compass data records - lower case 'c' entries denoting bad readings. (directory compass)
5. **gp1/2..d<jday> files.** These are simply formatted raw GPS data files. The data is formatted as 3 columns, decimal hours, longitude and latitude. Positions are in decimal degrees. (directory gps)



### Source Array, Streamer & Compass Bird Configurations

The source array configuration and the locations of the GPS receivers were fixed during the experiment (Table 1). There were 3 different streamer and compass bird configurations used during the ARAD experiment. The first two were employed relatively briefly at the beginning of the experiment, while the third was used for the majority of the MCS shooting (Table 1). The setup of the GPS receivers and source array were constant during the experiment (Table 2). The principal difference between the first and second configuration is an increase in the offset to the nearest receiver group and compass bird, while for the third configuration a pair of depth control only birds were added between the nearest pair of birds that reported compass headings (Tables 3 & 4, Figure 1).

The compass heading birds were a combination of 4 Digicourse birds owned by LDEO and 8 birds rented for the experiment directly from Digicourse. The Digicourse birds were at locations 2,3,4,6,7,8,10 & 11 along the streamer and the Lamont birds were at 1,5,9 & 12, with bird 12 moving to position 14 after the addition of the two depth control birds (birds, like hydrophone groups are numbered starting at the far end of the streamer and working forward) (Figure 1). Compass bird 12/14 worked only briefly at the beginning of the cruise and gave no measurements after JD264.

| Dimension                     | Offset (m) |
|-------------------------------|------------|
| Starfix GPS receiver to Stern | 45.9       |
| Trimble GPS receiver to Stern | 54.6       |
| Stern to center of Gun Array  | 39.6       |
| Starfix to Gun Array          | 85.5       |
| Trimble to Gun Array          | 94.2       |

**Table 1:** Source array and GPS configuration

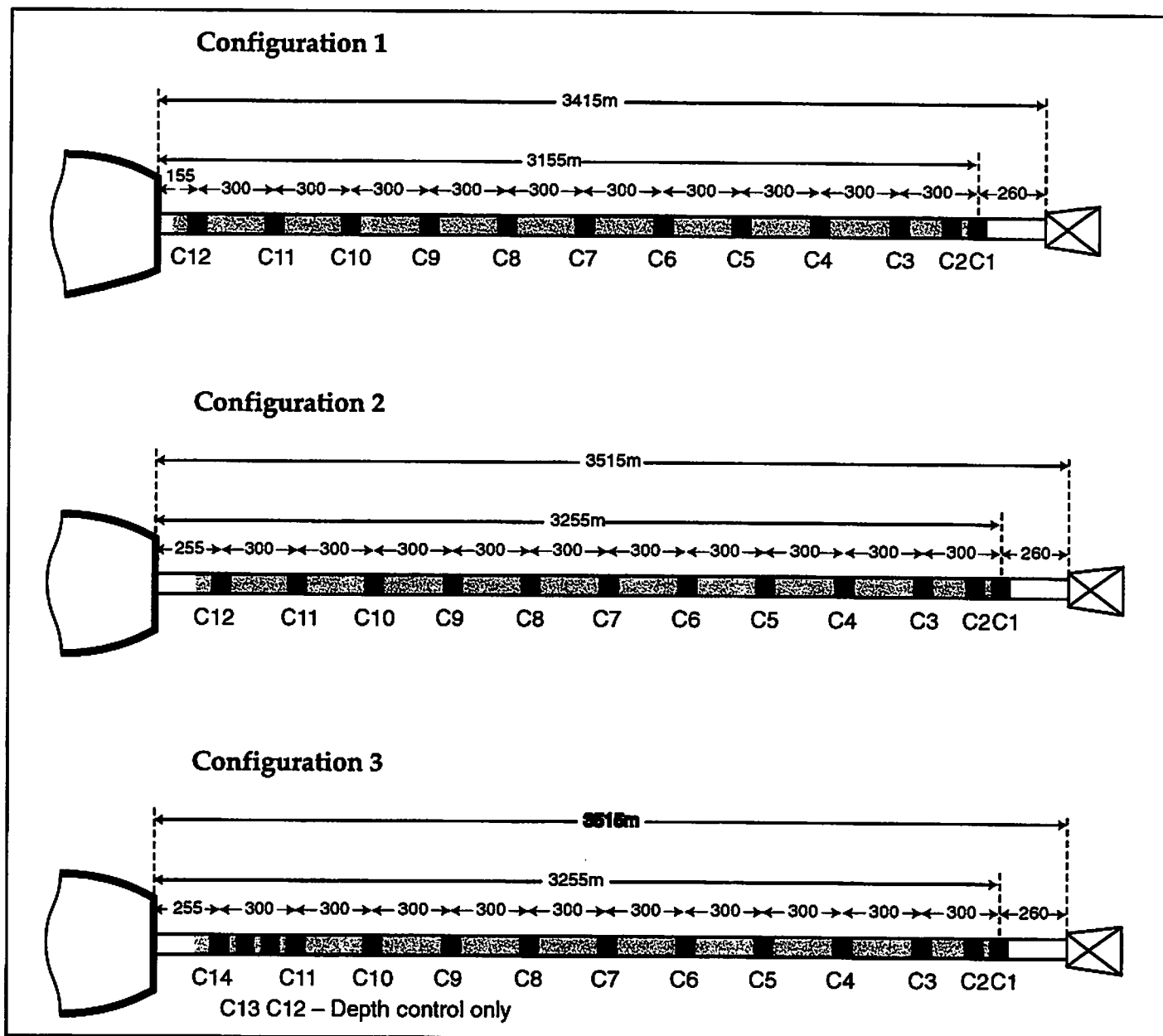
|                        | Start Date | End Date   | Lines   |
|------------------------|------------|------------|---|
| <i>Configuration 1</i> | 259 14:55z | 260 04:36z | OBS L, test 2   |
| <i>Configuration 2</i> | 260 09:47z | 264 07:10z | OBS A, B, C, F, I, J, K, M, N & P<br>MCS 201,168, 135, 102, 69, 36, & 3 |
| <i>Configuration 3</i> | 264 07:11z | 293 14:06z | All other lines   |

**Table 2:** Duration of streamer configurations

| Streamer Configuration            | 1      | 2      | 3      |
|-----------------------------------|--------|--------|--------|
| Number of receiver groups         | 124    | 124    | 124    |
| Group Interval (m)                | 25     | 25     | 25     |
| Stern to center of nearest group  | 67.5   | 167.5  | 167.5  |
| Stern to center of furthest group | 3142.5 | 3242.5 | 3242.5 |
| Last receiver group to tail buoy  | 260    | 260    | 260    |
| Minimum source-receiver offset    | 27.9   | 127.9  | 127.9  |
| Maximum source-receiver offset    | 3102.9 | 3202.9 | 3202.9 |
| Tail Buoy Offset                  | 3415   | 3515   | 3515   |

**Table 3:** Configuration of hydrophone groups in streamer





**Figure 1.** Streamer Configurations employed during ARAD. Light gray box indicates extent of hydrophone receiver groups. Black squares indicate positions of compass birds which are regularly spaced at 300 m intervals down the streamer except C2. In configuration 3, the darker gray squares indicate position of depth control birds.

The individual measurement of the compass bird had a precision of 10 bits or  $360/1024 = 0.35^\circ$ , but the readings telemetered to the ship are 12 bit values that represent averages of a series of measurements and thus have a nominal accuracy of  $\sim 0.1^\circ$ .



## Streamer Navigation Files

Available as part of the end of cruise day files are two sets of streamer navigation files, prefix cb1, one based on the Trimble GPS locations and the other on the John Chance Starfix GPS receiver (GPS #2). The streamer navigation files are a combination of shot time navigation files, prefix ts, gyro compass headings for the Ewing, and heading data from the compass birds, identical to that recorded in the MCS trace 0 data. The bird depth data that is also part of the trace 0 dataset is not recorded in the cb1 files.

On board, the Trimble GPS locations were used exclusively as the basis for the real time streamer navigation. However the Starfix locations are considered more accurate and reliable and have been used as the basis for the post-cruise renavigation. The following caveats should be borne in mind when using the cb1 files supplied at the end of the cruise, particularly the Starfix based files in the subdirectory ew9707.chance\_gps –

- The compass bird data in the cb1 files is incorrectly matched with the shot and navigation data for the first 5 days of shooting, day 259-264, persisting up to the end of digicon line obh-mabc and including arad-1, the first set of 6 MCS lines. During arad-1, there was a 3 shot delay in the writing of the compass bird data introduced by the Ewing real time system. Thus, for example, the compass bird data that should have been output with shot 8362 was actually output with shot 8365 in the compass bird files.
- The cb1 files in the ew9707.chance\_gps directory has the correct Starfix gps navigation only up to the end of day 269, and the cb1 files for all subsequent days still have the trimble navigation. The Starfix navigation can be obtained from the corresponding ts files.
- There is no Starfix navigation data in the ts files for the last 9 shots of day 262 (line 002) and the first 6 shots of day 292 (line 197). These locations must be interpolated from the raw Starfix GPS data.

The problem with the delay in the recording of the heading information in the cb1 files was discovered by comparing the compass bird files, cb1 files, with the information in Trace 0 of the MCS data. The compass bird data in trace 0 – heading and depth – has a time stamp that shows it was recorded 3-4 secs after the previous shot and thus there was always a 1 shot delay in this data. The data in the cb1 files was originally delayed 2 shots relative to trace 0, producing a total delay of 3 shots. From arad-2 onwards, the compass data in the cb1 files is correctly matched with the shot instant, modulo the 3-4 scan delay, and is 1 shot ahead of the information in trace 0.

## Streamer Log

**J259 (9/16) 14:55z Start of shooting, test1, OBS line L** The streamer was deployed in *Configuration 1*, with 155 m from the stern of the Ewing to the nearest compass bird. There was one active section, 4 groups, ahead of the first compass.

**J260 (9/17) 04:36-09:47z Between test2 and test3, OBS line N** The streamer was reconfigured adding a 100 m passive section to the front end, producing *Configuration 2*.

**J262 (9/19) 04:42 z Start of MCS shooting, arad-1, line 201** The shots for arad-1 start at 2001, but shots 2013 to 2999 are missing due to a recording system reset. Shots are essentially continuous from shot 3000. The start of line 201 is at shot 3077.

**J262 (9/19) 06:24z arad-1 shot 3349 during line 201** Starfix GPS navigation is available in the ts navigation files. There is raw Starfix navigation available from 06:21z, but for the first part of line 201 only Trimble navigation is available.



**J263 (9/20) 06:11z End of arad-1, line 003** Six MCS lines, 201, 168, 135, 102, 069, 036, and 003 were shot during arad-1 with *Configuration 2*.

**J264 (9/21) 01:54 z – 07:10 z End of obh-mabc** The recording of compass bird data was disabled while the problem of the delay in recording the compass bird information was fixed.

**J264 (9/21) 07:11 z Start of arad-2, line 199.** The streamer configuration was modified prior to the start of the line, producing streamer *Configuration 3*. To make the front of the streamer ride better, 2 depth control birds were added to the 2 streamer sections between the nearest pair of compass birds. As a result, the compass heading bird nearest the ship became bird C14 rather than C12, and the two depth control birds were C12 & C13.

**J264 (9/21) 23:12z line 067, shot 12662.** This was the last shot for which compass bird C14 nearest the ship recorded any heading data.

**J269 (9/26) 23:58z line002, shots 39006-14** The original Starfix navigation files, ts.n269 and cb1.n269 contain NaN for the ship location for the last 9 shots, 39006-39014, of day 269. The locations must be reconstructed from the raw GPS data.

**J270 (9/27) 10:26z line 039** Radar fix on tail buoy. Bearing 256.1°, distance 1.98-2.0 Nm, heading 76.8°, course made good, 75.0°.

**J271 (9/28) 06:59z line 045** Radar fix on tail buoy. Bearing 248.0°, distance 1.96 Nm.

**J274 (10/1) 11:03z line 090 (Tuna line), shot 62430** Evasive action to miss tuna boat started at 11:03z and a gun was out the water at 11:06z. Data is good to shot 62430.

**J278 (10/5) 21:48z Abandon line 105, shot 86374** First attempt to shoot line is aborted at this point.

**J280 (10/7) 08:58z Abandon line115, shot 94197** First attempt to shoot line is abandoned at this point.

**J283 (10/10) 09:56z, Abandon line139, shot 109369** First attempt to shoot line is abandoned at this point 10.250 km along the line.

**J283 (10/10) 11:55z, Return to line139, shot 109766** The line is rejoined 4.785 km along the line and repasses the point at which the first attempt was abandoned at shot 109952. The two attempts are patched together to form a single line at 10.0 km shots 109363/109905.

**J287 (10/14) 20:23–20:43z line 192 reshoot, shots 131433–131508** Graham and Satish run a series of 37 tailbuoy readings from the Ewing rescue boat using a Garmin handheld GPS receiver. During the readings the rescue boat was offset ~10 m from the tailbuoy but maintained a roughly parallel path.

**J290 (10/17) 04:26z** Frequency of GPS sampling increased to once every ~2 s. This increases the systematic error in processed positions to ~30 m.

**J292 (10/19) 00:00z line 197 shots 152405–10** The original Starfix navigation files ts.n292 and cb1.n292 contain NaN for the ship location for the first 6 shots , 152405–152410 of the day. The locations must be reconstructed from the raw Starfix GPS data.

**J293 (10/20) 14:06z, End of arad-4, Ω-line** MCS recording ceased at this point an streamer was recovered.



## Estimation of Compass Heading Biases

The streamer headings received from the compass birds contained a consistent set of offsets that persisted throughout the ARAD experiment. These heading offsets are most noticeable when the streamer was pulling almost directly behind the ship with little or no feathering. In these cases, the heading measurements showed a characteristic saw-tooth pattern that dominated over the systematic change in heading along the streamer. The sign of the offsets reversed when the sail direction switched, i.e. the offset for a given bird was consistently either to the left or right of the mean streamer heading (Figure 2). The magnitude of the heading offsets, up to  $3^\circ$ , was well outside the specified accuracy of  $0.1^\circ$ . After the cruise, Digicourse in response to our concerns, reran the calibration tests on their compasses and confirmed that the headings were within spec.

To investigate the problem, a set of MCS line sections with small feathering angles were chosen subjectively from the ARAD dataset. This initial set was winnowed further by eliminating lines for which the mean heading angle was in fact greater than  $1^\circ$  from the sail direction and also lines above a noise threshold,

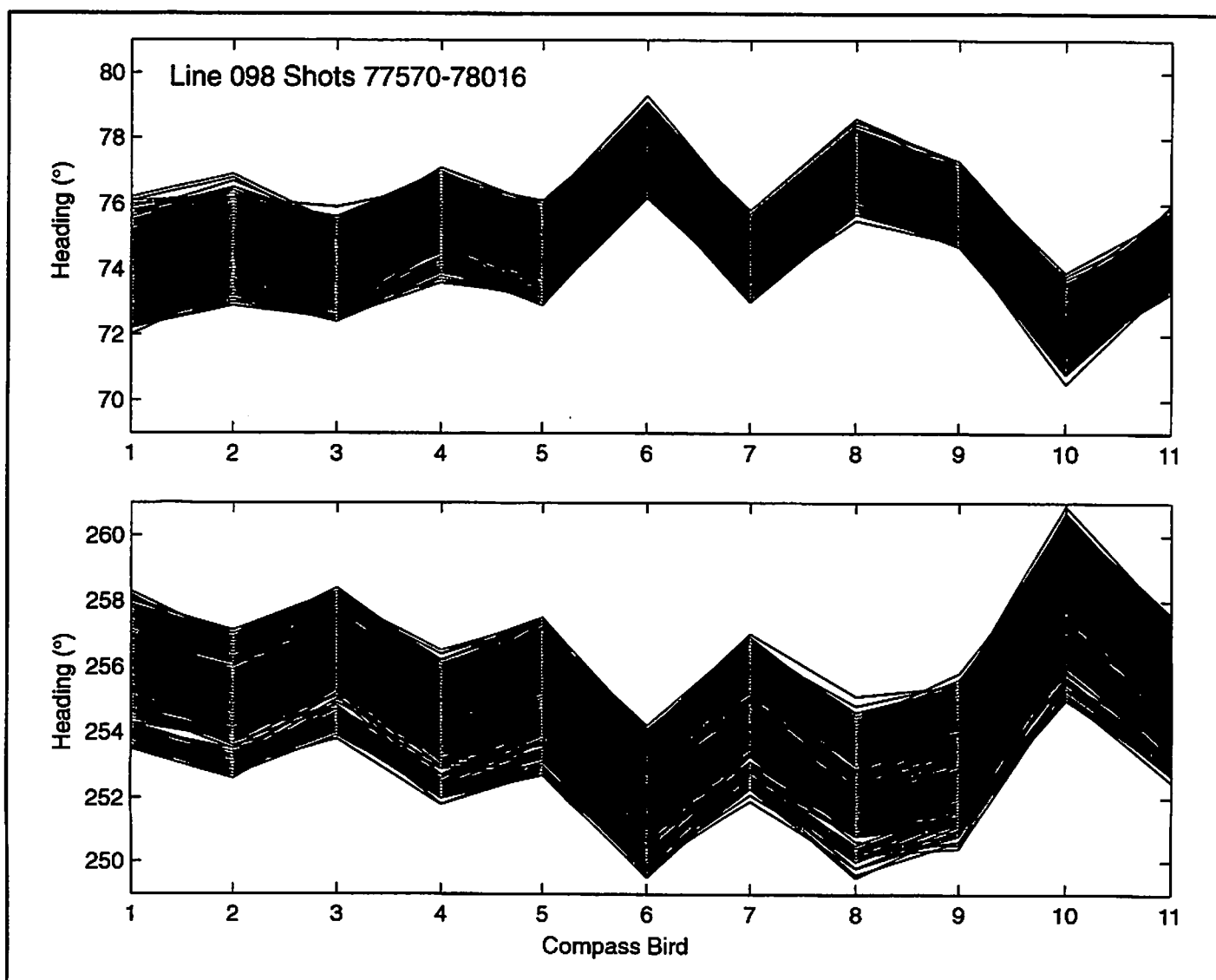


Figure 2. Compass bird headings for lines 093 and 098. (a) All compass bird readings for line 093, day 277, a W- E line, mean heading  $75^\circ$ , for 447 consecutive shots from 6 to 23 km along the line. (b) All compass bird readings for line 098, day 275, a E- W line, mean heading  $255.1^\circ$ , for 476 consecutive shots from 5-23 km along the line. Lines in shot in either direction show a characteristic sawtooth pattern in heading direction, although the sign of the pattern is flips.



which was set at a mean absolute difference between successive readings of  $0.4^\circ$ . This left parts of 27 lines:  
W->E 23,57,87,93,109,113,123,163,197  
E->W 2,4,10,28,52,56,72,98,110,132,136,144,148,176,178,188,192

East-west lines predominate since this was the sail direction into the prevailing currents. The final set of lines span almost the entire experiment but excludes days 262-266 at the beginning and days 283-286 when the influence of hurricanes produced rough sea states and/or strong inertial currents. Since the early part of the cruise is absent there is no readings from compass 12/14 nearest to the ship in the dataset.

The magnitude of the offsets relative to the mean heading is stable over the entire experiment and is similar in either direction, Figure 3. This observation is corroborated by the results of bootstrapped, least squares inversions using different subsets of the data. The inversions, which used 50 or 100 randomly chosen sets of compass measurements, assumed that the heading of the streamer was constant or possibly linearly varying and the individual measurements were the sum of the heading and a compass offset or bias. To eliminate ambiguity, the sum of the biases was constrained to be zero and, when appropriate, to have zero overall trend. The mean biases and corresponding standard deviations were estimated from bootstrap samples of a 100 inversions. The standard deviations were typically  $0.1^\circ$  or better, comparable to the nominal heading accuracy of the compasses. The bootstrapped inversions compared offset estimates for constant versus linearly varying heading, east versus west sail lines, and different periods of the ARAD experiment, Figure 4. The differences between the offset estimates are occasionally large enough to be considered statistically significant, for example the bias for compass 3 differs by  $0.6^\circ$  between the east and west sail directions. But the overall shape of the biases is consistent and the difference in overall heading between different solutions is less than  $0.2^\circ$ , corresponding to a change in geophone location of less than 10 m. The reference bias solution chosen for use in the ARAD navigation is the one based on all the data and the assumption of a constant streamer heading

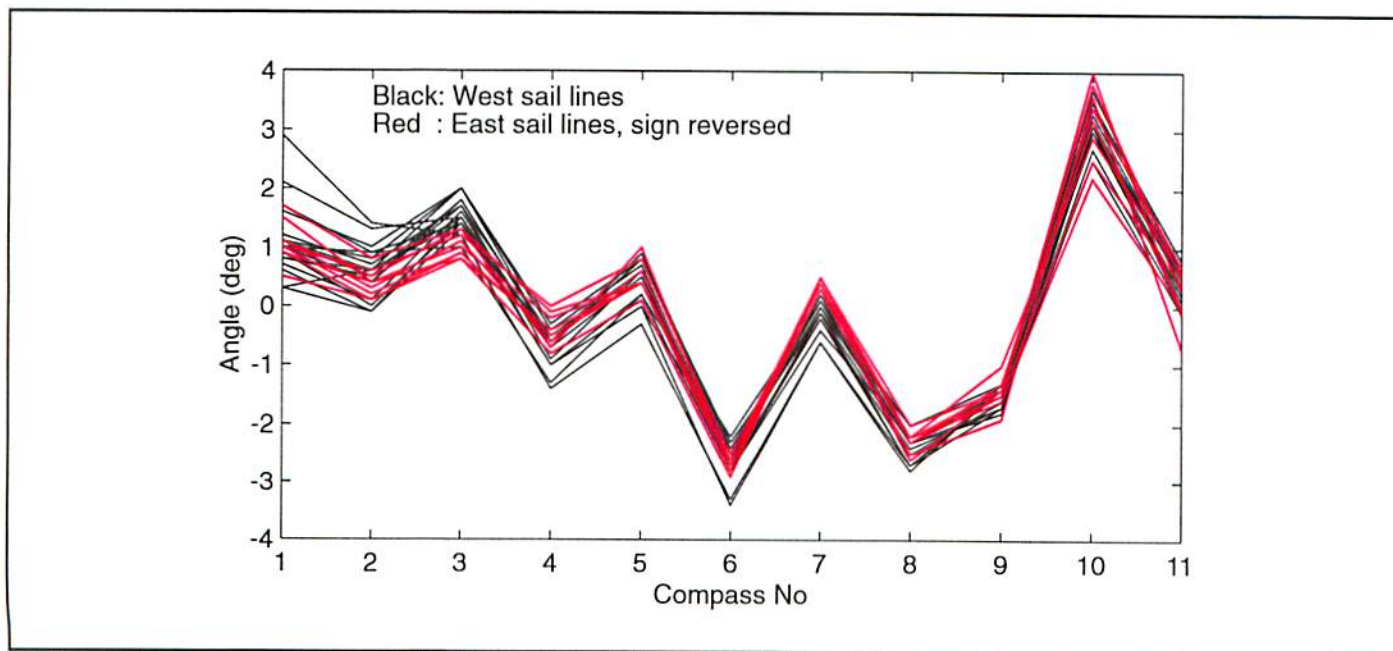


Figure 3. Mean compass offsets for the 27 study lines. Offsets are calculated relative to the mean heading of all compasses over the entire MCS line section. The sign of the offsets for the east sail lines (heading  $\sim 75^\circ$ ) has been reversed. The magnitude of the offsets is consistent over the entire experiment and the change in directions.



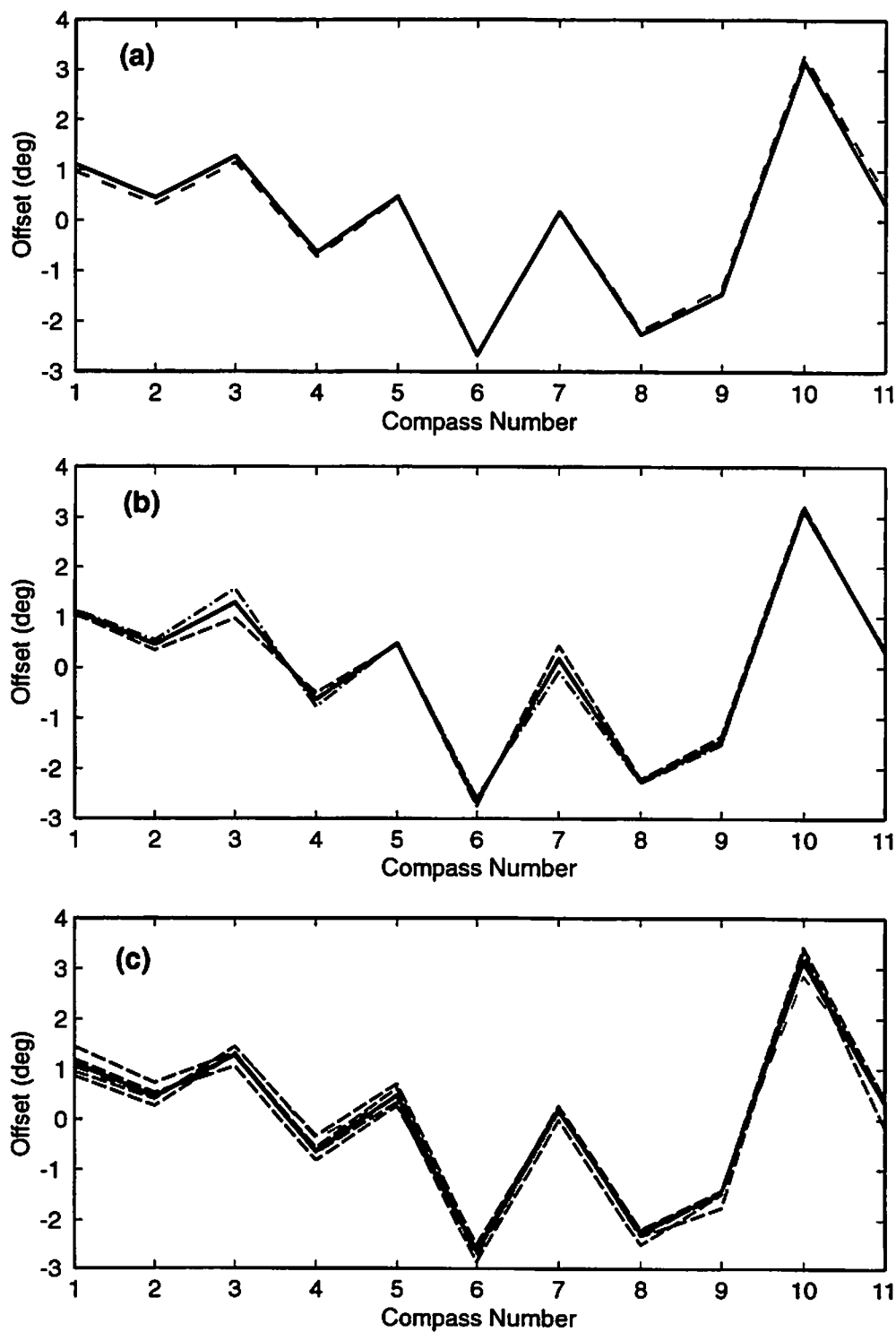


Figure 4. Comparison of bootstrap estimates of offsets. In all panel the thicker solid line is the estimate using all data and assuming that the underlying streamer heading is constant. (a) Comparison with the offsets assuming a linear heading variation. (b) Comparison with estimates derived either from only east sail lines (dash line) or only west sail lines (dash-dot line). (c) Comparison with estimates from different time periods, days 267-270, 271-275, 276-280, 281-286, 287-292



| Compass | Offset(°) | Std Error |
|---------|-----------|-----------|
| C01     | 1.11      | 0.09      |
| C02     | 0.46      | 0.08      |
| C03     | 1.28      | 0.06      |
| C04     | -0.63     | 0.05      |
| C05     | 0.48      | 0.05      |
| C06     | -2.67     | 0.05      |
| C07     | 0.18      | 0.04      |
| C08     | -2.26     | 0.05      |
| C09     | -1.45     | 0.06      |
| C10     | 3.17      | 0.08      |
| C11     | 0.33      | 0.08      |

Table 1 Estimates of compass offset or bias Values are from the mean of bootstrap estimates assuming that the underlying streamer heading is constant..

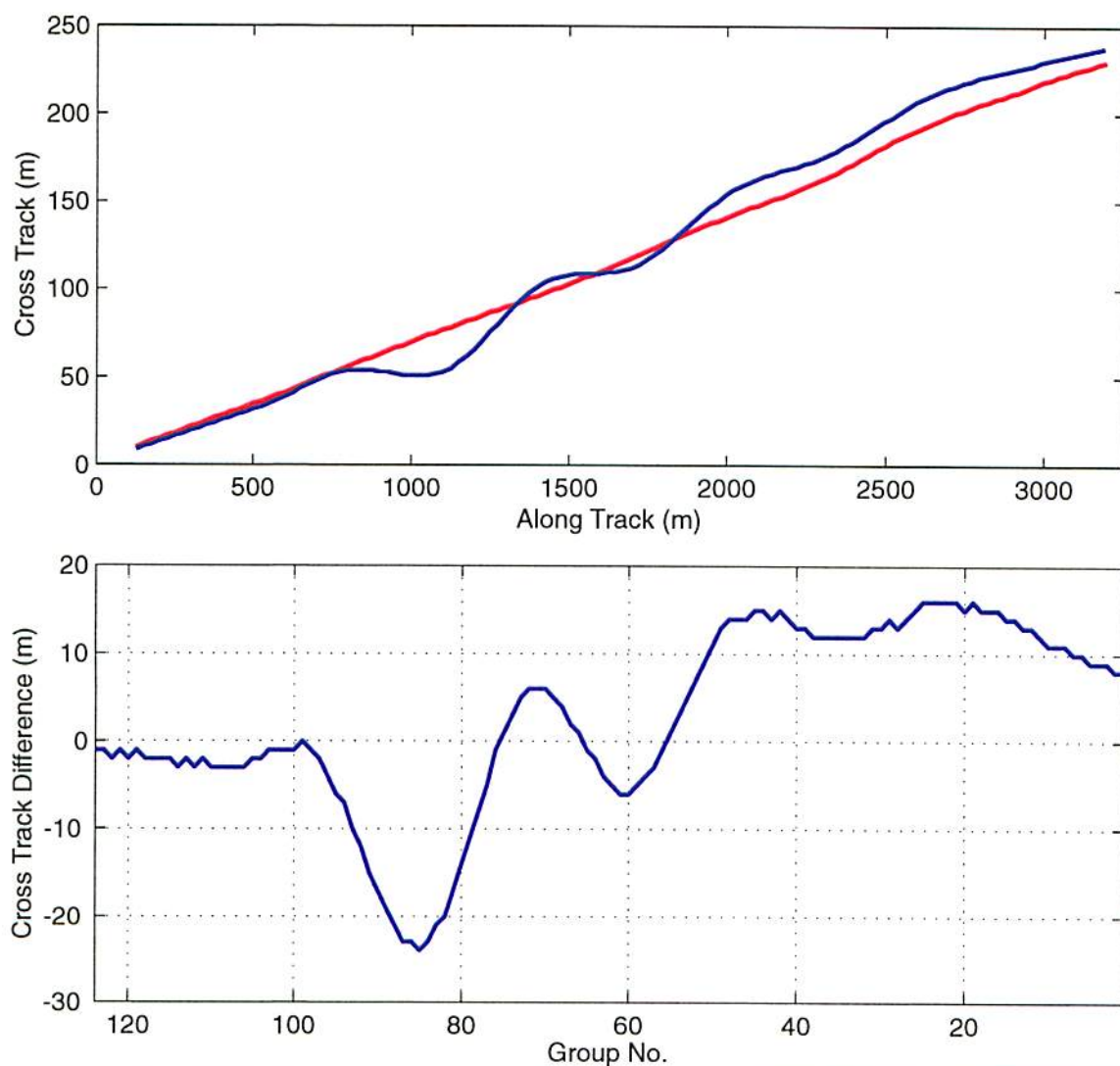


Figure 5. Comparison of Streamer reconstructions with and without bias corrections. The reconstructions shown are for shot 131470 of line 192 when tailbuoy measurements were made. The red line in the top panel is with the bias corrections included and the blue is without. The lower panel is the difference in the cross track direction, locally differences are over 20 m near group 85.



Although the offsets are consistent, there remains the question of whether they reflect actual heading variations and the shape of the streamer or are biases in the compass measurements. If the heading variations are real, the consistency of the offset pattern and the fact that it reverses with the sail direction suggests that it is tied to some asymmetry in either the wake pattern or towing setup of the Ewing: an oscillating heading is not expected for a streamer under tension subjected to a steady cross current.

It should be noted that while the application of the compass biases produces a smoother streamer reconstruction, the imposition of the constraint that the sum of the biases be zero means that there is only a minor difference in the overall trend and, for example, the location of the furthest geophone group, group 1, and the tail buoy is almost identical. These corrections account only for relative heading errors but not for any systematic bias in the headings. The question of systematic bias is addressed in the next section on the tail buoy GPS measurements.

## Tail Buoy Measurements

During the reshoot of line 192, on day 287 (10/14), Graham Kent and Satish Singh took GPS measurements of the tail buoy location using Paul Henkart's Garmin hand held receiver, while traveling parallel to the tail buoy in the Ewing's rescue boat. The rescue boat's course kept pace with the tail-buoy while maintaining an offset towards the south of between 5 & 10 m. A total of 37 measurements were made over the time interval from 20:23:00 z to 20:42:30 z, covering shots 131434 to 131507. Line 192 was a west sail line, heading  $255^\circ$  and started at 19:50z. The Garmin GPS measurements were thus made near the start of the line, and started just after the streamer had finished straightening out from the turn.

In Figure 6, the GPS measurements from the Garmin are compared with GPS measurements from the R/V Ewing – the differential GPS measurements of the Starfix & Trimble receivers and the standard GPS measurements of the two Magnavox receivers. To facilitate comparison, the positions are plotted in along track and cross track coordinates and the Garmin positions have been adjusted for the offset between the Starfix antenna and tail buoy using the streamer reconstruction results. The variable 20-50 m offsets between the Magnavox and Starfix locations represent the time varying error in the non-differentially corrected GPS measurements. This error is also clearly present in the Garmin positions and needs to be accounted for when considering the accuracy of the streamer location. The constant offset between the different GPS measurements reflects the difference in the various GPS antenna locations aboard the *R/V Ewing*. A differential GPS correction was generated from these measurements and applied to the Garmin tail buoy measurements.

A comparison of the estimated tailbuoy position from the compass bird solution and the differentially corrected Garmin positions is shown in Figure 7. The reconstructed cross track position of the tail buoy closely tracks the measured position and the cross track displacement increases from 140 m to 250 m (Fig 7. top panel). The mean difference between the measure and reconstructed cross track displacement is 16 m (Fig. 7 middle panel) about half of which can be accounted for by the offset of the rescue boat from the tail buoy. The cross track error is sensitive to errors in the compass bird headings, and subsequent streamer reconstruction. A 10 m cross track error corresponds to an approximately  $0.2^\circ$  average heading error, which is in line with the nominal accuracy of the birds. Thus although there appears to be biases in the individual compass bird headings there appears to have been no overall bias.

There is on average a 14 m along track difference in the measured and reconstructed tail buoy positions. The sense of the error is such that the measured tail buoy location is further from the ship than the reconstructed location. In the absence of additional measurements the source of this error is not clear. It may be due simply to an error in the measurement of one of the streamer sections, even though these were carefully measured upon streamer recovery. However, the variation in the along track error is large enough that this is not a particularly convincing explanation. The difference may also be due to vertical displacements of the streamer, although the size of the error is much larger and more variable than would be expected.



| <b>Time<br/>(UTC)</b> | <b>Longitude<br/>(Decimal Degrees)</b> | <b>Latitude<br/>(Decimal Degrees)</b> |
|-----------------------|--|---------------------------------------|
| 20:23:00              | -104.13097                             | 8.99567                               |
| 20:24:00              | -104.13207                             | 8.99548                               |
| 20:25:00              | -104.13340                             | 8.99523                               |
| 20:26:00              | -104.13490                             | 8.99498                               |
| 20:26:30              | -104.13563                             | 8.99485                               |
| 20:27:00              | -104.13632                             | 8.99480                               |
| 20:27:30              | -104.13693                             | 8.99473                               |
| 20:28:00              | -104.13755                             | 8.99465                               |
| 20:28:30              | -104.13815                             | 8.99463                               |
| 20:29:00              | -104.13870                             | 8.99468                               |
| 20:29:30              | -104.13928                             | 8.99453                               |
| 20:30:00              | -104.13985                             | 8.99438                               |
| 20:30:30              | -104.14040                             | 8.99423                               |
| 20:31:00              | -104.14102                             | 8.99405                               |
| 20:31:30              | -104.14172                             | 8.99388                               |
| 20:32:00              | -104.14238                             | 8.99362                               |
| 20:32:30              | -104.14300                             | 8.99347                               |
| 20:33:00              | -104.14362                             | 8.99328                               |
| 20:33:30              | -104.14442                             | 8.99307                               |
| 20:34:00              | -104.14498                             | 8.99292                               |
| 20:34:30              | -104.14567                             | 8.99285                               |
| 20:35:00              | -104.14628                             | 8.99273                               |
| 20:35:30              | -104.14693                             | 8.99257                               |
| 20:36:00              | -104.14753                             | 8.99243                               |
| 20:36:30              | -104.14815                             | 8.99237                               |
| 20:37:00              | -104.14880                             | 8.99213                               |
| 20:37:30              | -104.14947                             | 8.99195                               |
| 20:38:00              | -104.15012                             | 8.99175                               |
| 20:38:30              | -104.15080                             | 8.99147                               |
| 20:39:00              | -104.15140                             | 8.99130                               |
| 20:39:30              | -104.15213                             | 8.99098                               |
| 20:40:00              | -104.15287                             | 8.99092                               |
| 20:40:30              | -104.15360                             | 8.99050                               |
| 20:41:00              | -104.15420                             | 8.99022                               |
| 20:41:30              | -104.15508                             | 8.98998                               |
| 20:42:00              | -104.15572                             | 8.98993                               |
| 20:42:30              | -104.15642                             | 8.98975                               |

Table 2 Garmin GPS measurements of tail buoy



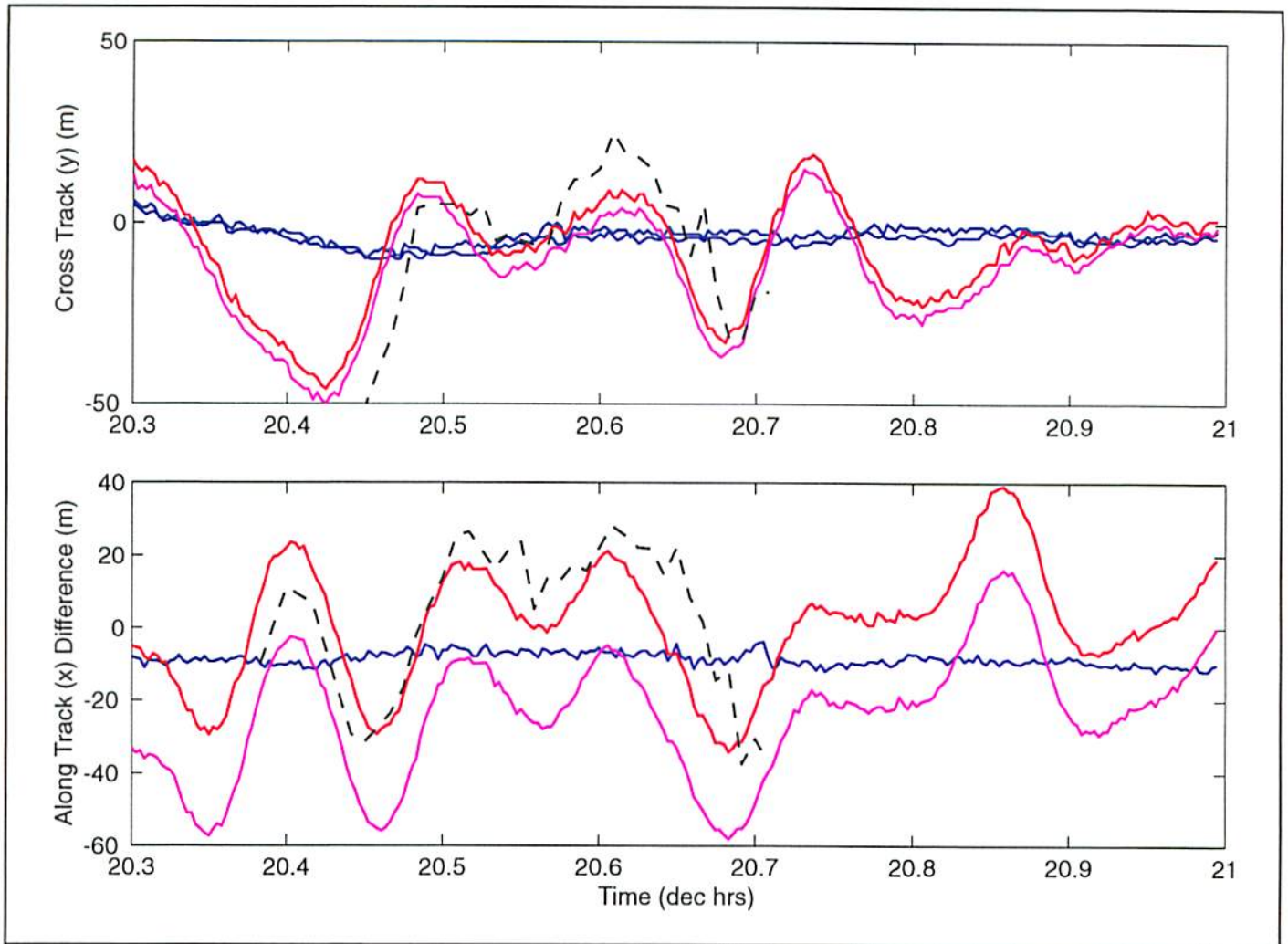


Figure 6. Ewing GPS data for the period 20:18 to 21:00z on line 192. The top panel shows the absolute cross track position of the ship as measured by different GPS receivers, while the lower panel shows the differences in the along track position relative to the Starfix position. The Trimble output is in blue and the Starfix output is in solid black (top panel only). Both receivers are in differential GPS mode. The red and magenta lines are, respectively, outputs from Magnovox GPS receiver 1 & 2. The black dashed lines are the Garmin GPS measurements shifted down by 220 m in the top panel and forward 3660.9 m, the straight line distance from the Starfix antenna to the tail buoy.

## Streamer Reconstruction

The streamer shape was reconstructed from the compass bird headings by first interpolating a direction for the entire streamer and then integrating the directional data starting from the stern of the ship. The compass bird data was interpolated using a quadratic spline. The angular behavior of the streamer between compass birds  $i$  and  $i+1$  was thus assumed to be of the form

$$\theta = \theta_i + k_i s + b_i s^2 \quad 0 \leq s \leq l_i$$

where  $s$  measures distance along the streamer from compass bird  $i$  and  $l_i$  is the distance between successive compasses. The interpolation forces continuity of direction,  $\theta$ , and curvature,  $d\theta/ds$ , at each compass bird. The specification of the interpolation problem is completed by setting the curvature to zero at the first and last compass bird, equivalent to demanding that the streamer be straight between the stern attachment point and the first bird, and between the last bird and the tail buoy. The integration of the direction used length increments,  $ds$ , equal to the group spacing of 25 m so that the intermediate  $(x,y)$  positions from the integration would be the required group locations.



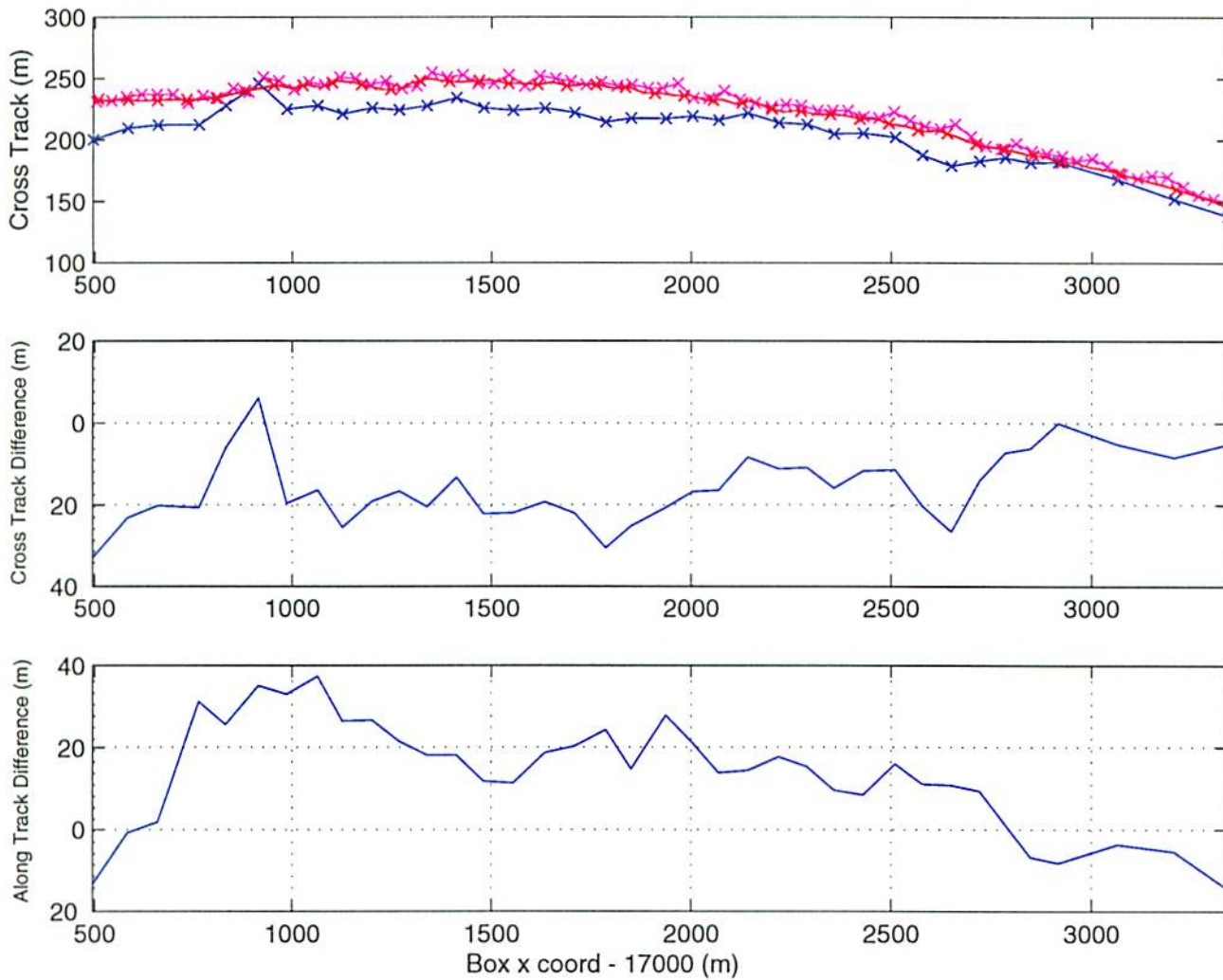


Figure 7. Top: A comparison of the cross track position of the tail buoy as measured from the rescue boat using the differentially corrected Garmin GPS locations (blue line) and estimated from streamer reconstructions using compass bird data. Red line is from bias corrected compass bird headings and magenta is from the uncorrected measurements. Increasing time corresponds to decreasing x coord. Middle: difference in cross track positions between the GPS measurements and bias corrected streamer reconstruction. Bottom: corresponding along track difference.

For the most part during the ARAD experiment, once the streamer had settled down after the turn, the compass bird headings were nearly constant along the streamer. In these circumstances, the difference between the chosen quadratic interpolation and a simpler linear interpolation is negligible, and the results from the previous section indicate that either reconstruction would be accurate enough. In the absence of continuous tail buoy data, it is not possible to independently check the accuracy of the reconstructions during and immediately after the turns. Fortunately data from more curved sections of streamer form only a small part of the 3-D dataset.

The streamer reconstruction relies on accurate compass bird headings since no allowance is made in the interpolation for measurement error. When the compass birds performed to specification with a heading accuracy of  $0.1^\circ$ , this was not a problem. However, visual inspection of the compass bird readings for each line



after the cruise revealed that heading accuracy was dependent on sea state, particularly at the beginning of the cruise when the front end of the streamer was poorly balanced and the sea state was the roughest. Figure 8a shows the compass bird data from line 003, shot on day 263 as part of arad-1 line, the first pass through the MCS box. The 3 compass birds nearest the ship in particular show high frequency noise but almost all compasses show occasional large noise glitches, perhaps due to data dropout. When MCS data collection was resumed the streamer had been rebalanced and two depth control birds added to the front end. This, in conjunction with better sea states greatly improved the reliability of the compass data. Figure 8b shows data from line 016 shot on day 271 after bias correction. All birds show low noise and the shot to shot variation in heading direction, after the streamer has settled down from the turn, is  $0.1-0.2^\circ$  in accord with the stated accuracy. In addition coherent waves of heading changes are seen propagating down the streamer, strengthening the believability of the data. The mean feathering angle of the streamer during line 016 was  $11.7^\circ$  so there were large surface currents at the time, but conditions were steady in contrast to the chop of the early lines.

As a result of the examination, we decided to apply a median filter to all compass bird prior to final streamer reconstruction and calculation of receiver locations. A median filter was chosen to ensure that all large noise spikes were cleanly removed from the data. The length of the filter was varied from line to line depending on the quality of the initial data. For good quality lines such as line 016, the filter length was typically 5-7 shots, but for noisy lines such as line 003, the filter length was increased to 13-19 shots.

## Real Time and Post Cruise Processing

The real time and post cruise processing was accomplished using a Matlab program "nav3d" initiated prior to ARAD but completed on board the R/V Ewing during the cruise, Figure 9. In real time, nav3d was used, among other things, to check the accuracy of ship navigation, the functioning of the compass birds, and the speed with which the streamer pulled through and straightened out behind the ship after each turn. The input to nav3d was read from a continuously updating compass bird file on the Ewing real time system "moray" using the Unix "tail" command. Data for a given shot was typically available a few seconds after the shot instance. Nav3d was also used aboard in a post processing mode to generate initial source and receiver locations for all shots. These in turn were used to generate preliminary bin maps (e.g. Figure 10) for the experiment and identify holes in the reflection coverage. Based on the binmaps 8 lines were chosen for reshooting 027, 071, 091, 096, 114, 124, 130 and 149. In subsequent processing a "2" was prepended to these lines to identify them as reshoots, thus the reshoot of line 027 is designated line 2027.

The final post cruise processing via nav3d used as input the filtered compass bird files for each line discussed above. These files are archived at Scripps in the directory */net/archive/optical/mcs/arad/navigation/compass* with file names of the form *compl<line\_no>.asc*. The data is stored in columns with the following format

```
<date:yr day hr mn sec> <shot no> <lat> <lon> <ship heading> <compass heading 1> ...
```

The output source-receiver locations for all shots of a line are stored in files with names of the form *line<line\_no>.cmp* and are stored in gzipped format at Scripps in the directory */net/archive/optical/mcs/arad/navigation/linexy*. The data is stored in columns with the following format

```
<date:yr day hr mn sec> <shot no> <group non> <shot x> <shot y> <receiver x> <receiver y>
```

The shot and receiver x-y locations are given in ARAD box coordinates. The files contain the receiver positions of all groups of any shot along the line for which at least one midpoint lies within the ARAD box x-limits of 0 and 20,000 m. At the top and bottom of the box the midpoint had to lie within 100 m of the edge of the box for the entire line to be include.



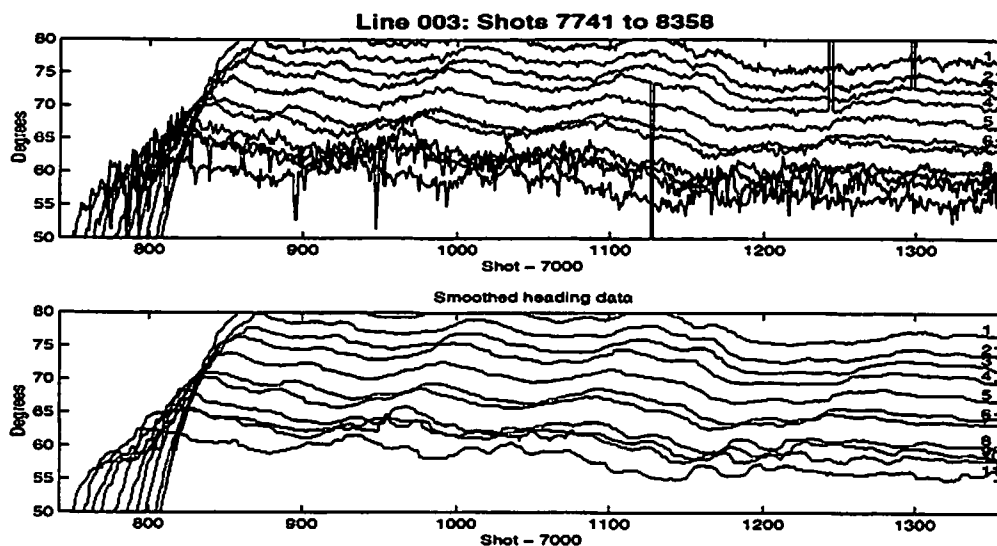


Figure 8a Raw (top) and filtered (bottom) compass bird heading data for line 003, shot during rough weather on day 263. Heading data has been offset by  $2^\circ$  per bird to improve clarity, Compass bird numbers are indicated at right, higher number correspond to birds nearer the ship. In the raw data, headings nearest the ship contain high frequency noise and spikes which are occasionally observed on all birds. The lower data has been median filtered with a window length of 13.

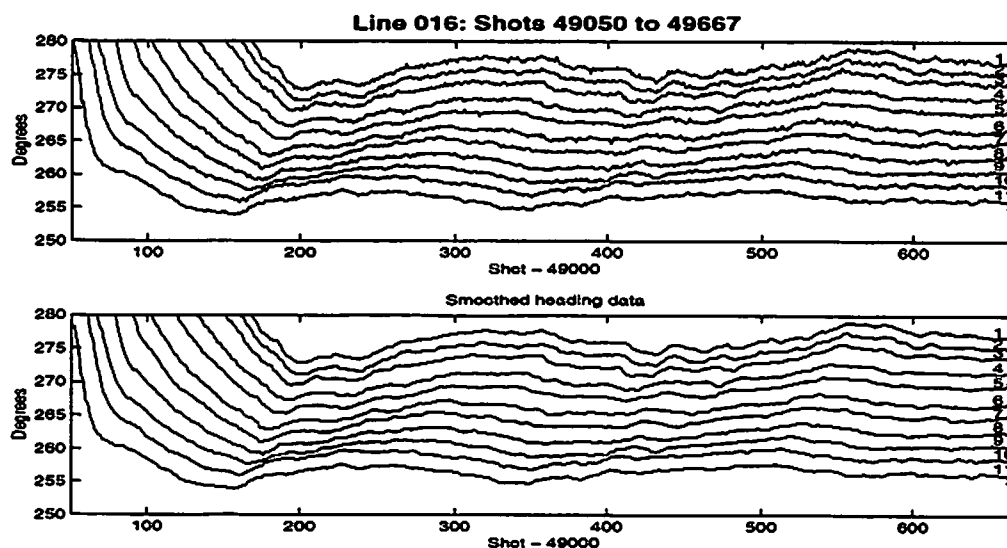


Figure 8b. Raw (top) and filtered (bottom) compass bird heading data for line 016 shot on day 271. This data is typical of calm weather data after the rebalancing of the streamer. The shot-to-shot noise level on the raw heading data is  $\sim 0.1$ - $0.2^\circ$ . The data was median filtered using a window length of 5.



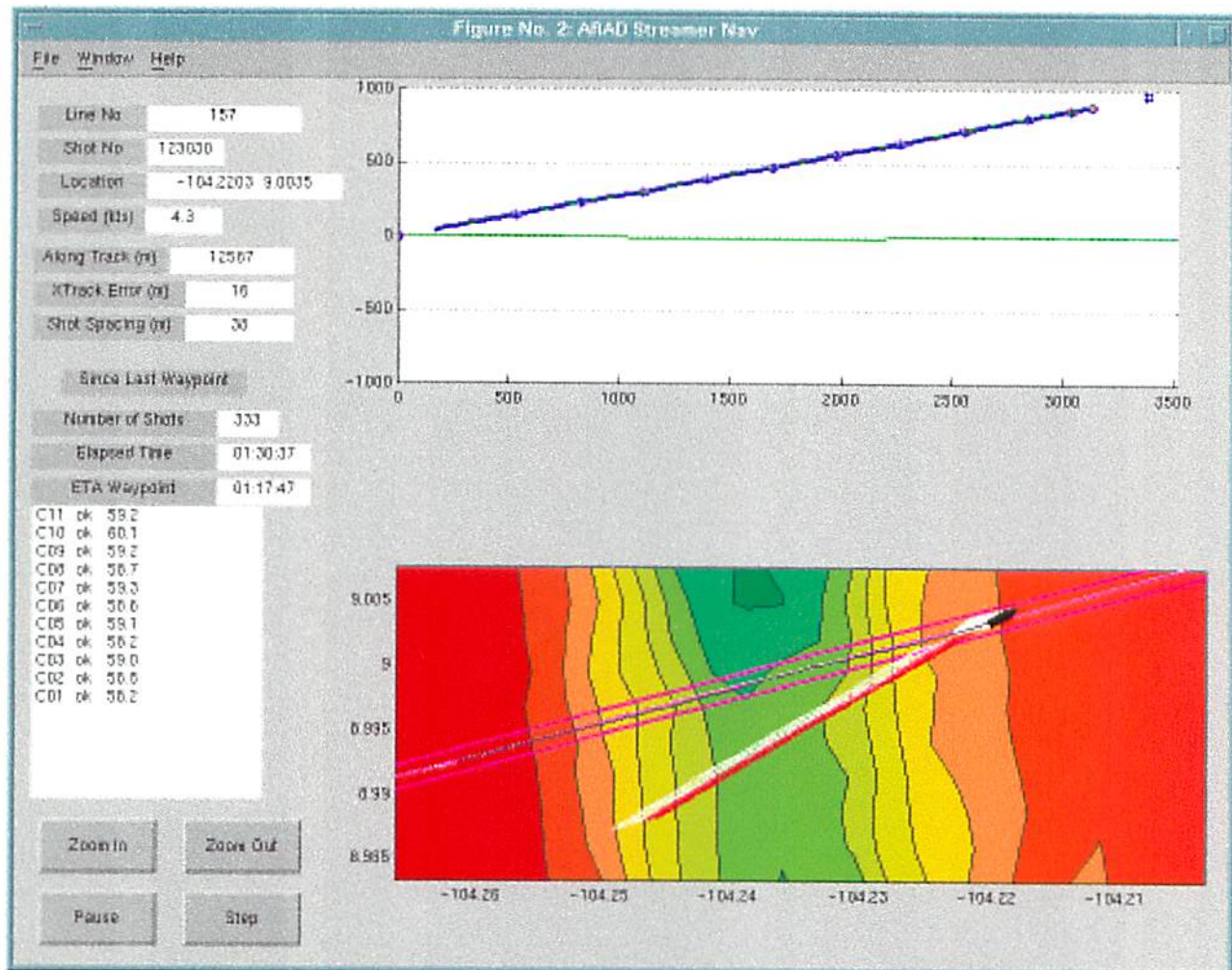
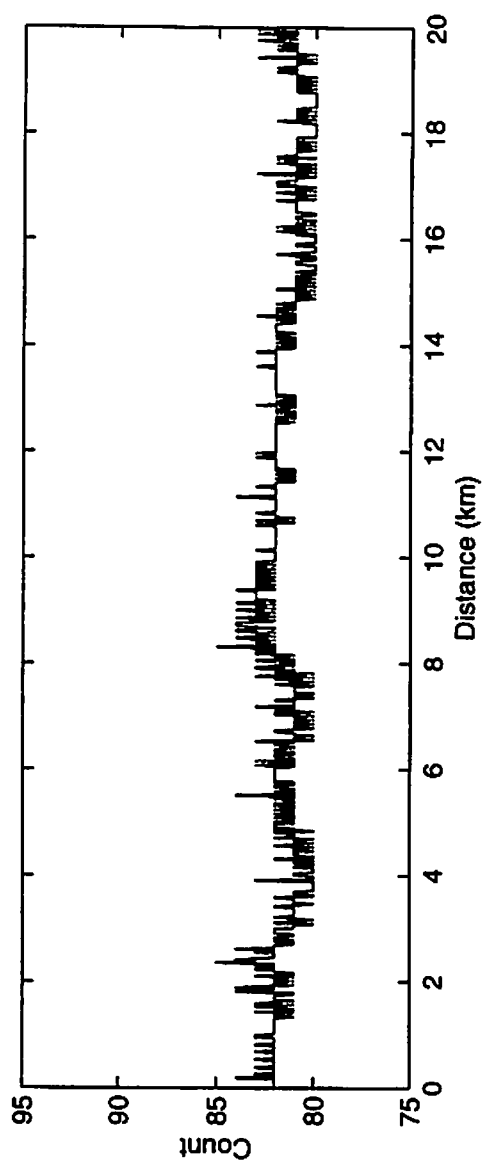
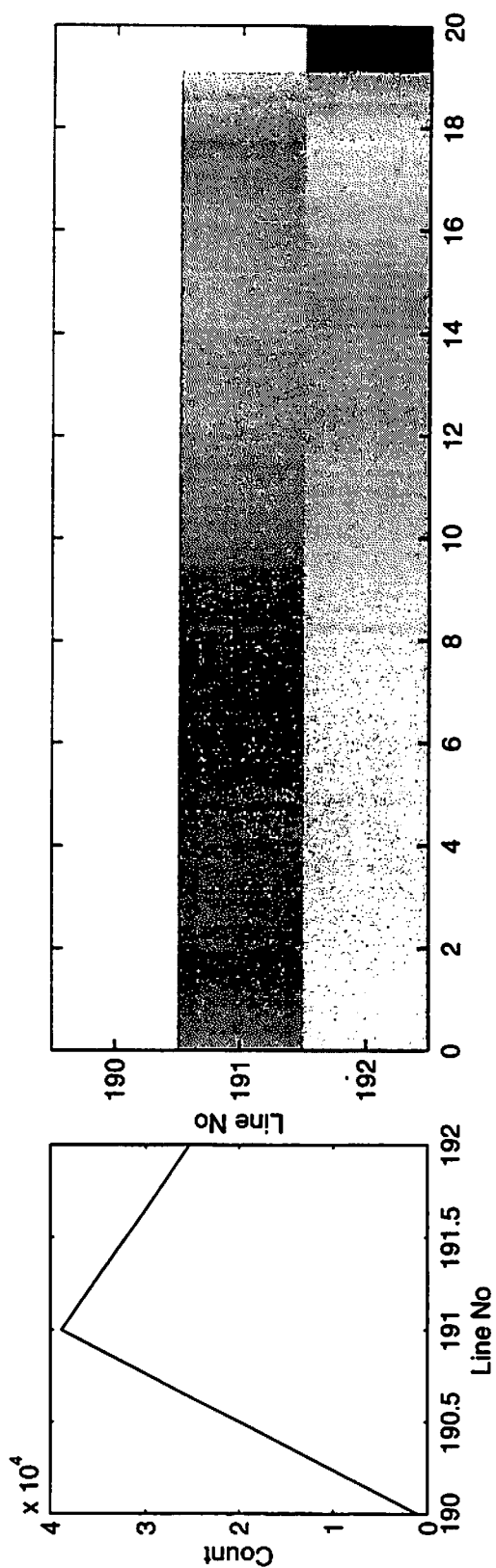


Figure 9. Screen shot from streamer navigation program “nav3d”. Top panel shows streamer reconstructions for the last 5 shots (blue lines) in a ship/line centered reference frame with the stern of the ship at the left of the panel. The green line records the displacement of the ship track relative to the current line. The bottom panel shows strip track and streamer relative to bathymetry. The current MCS line is in white and the adjacent MCS lines are in magenta.



# Line 192 Bin Map



line 192: 25298 17->83  
 line 191: 38821 0->62  
 line 190: 1097 0->12



## 5.0 Preliminary Cruise Assessment

### MCS Operations and Data Quality

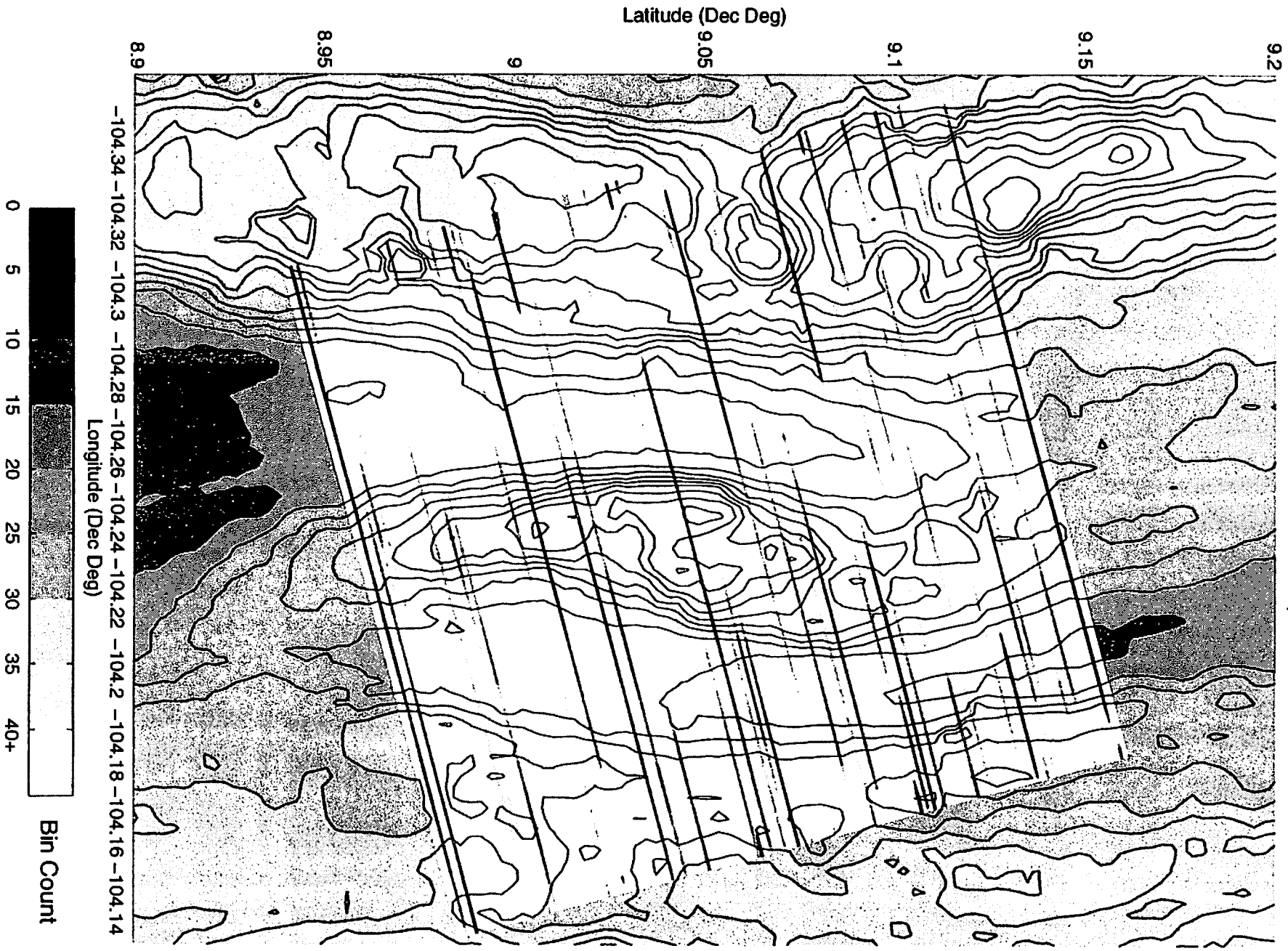
The 3-D reflection dataset was shot in a 20 km by 23 km grid (rotated N15°W due to blockage of the INMARSAT antenna by the *Ewing's* radar platform—future 3-D cruises should take note that the present INMARSAT configuration/geometry may result in total loss of reception, and no DGPS!!!) centered on the OSC basin; cross-track line spacing was nominally 100 m, with an along-track shot spacing of ~38 m. Approximately 31 days of continuous shooting were required to collect the MCS volume (13+ million traces). During the roughly 5 weeks of active shooting, 158,000 "MCS" shots were fired; to the credit of the *Ewing's* captain, science officer & crew, the acquisition system was down for < 24 hours—mostly due to gun failure shortly after 100,000 shots. Throughout the cruise, real-time streamer navigation was monitored and compiled to assess reflection bin coverage; subsequent to collecting the 201 required "sail lines", 8 additional lines were shot to fill-in the most serious gaps in data coverage due to streamer feathering. The resulting bin coverage (*Figure Final ARAD Reflection Bin Map*) is remarkably even with only minor dropouts which can be easily accommodated through bin-extension. The MCS profiles were brute stacked in quasi-real-time (20 minute delay) with a generic ridge-crest velocity function hung from the seafloor (Appendix 11); this process was for both QC purposes, and to catch any acquisition problems early on. Thereafter, these images were placed into a "flip book" to provide some insight into changes in crustal structure across the overlapper.

MCS data quality was excellent throughout the experiment, with the exception of a few "sail lines"—201, 168, 135, 102, 69 & 36—shot while Hurricane *Nora* was some 350 nm distant. A few other notable Hurricanes, namely *Linda*, *Olaf* and *Pauline*, also disturbed the local sea-state, but the data were not critically affected during these short periods. An example shotgather acquired during an unfavorable sea-state (#003080) is compared to a shotgather (#160056) more typical of wave conditions experienced throughout most of the experiment (*Figure Shotgather 160056/003080*). The combination of heavy seas, and no stretch-section near the ship's stern, sent waves along the streamer which was most problematic when the cable approached the surface (floated?) causing the noise level to ascend dramatically. Luckily, these noisy sections (with some effort) can be edited, and only represent about 2-3% of the total data collected during the MCS phase of the 3-D turkey shoot (OBH/S lines were also shot during this noisy period to make use of the unfavorable shooting environment for MCS data!).

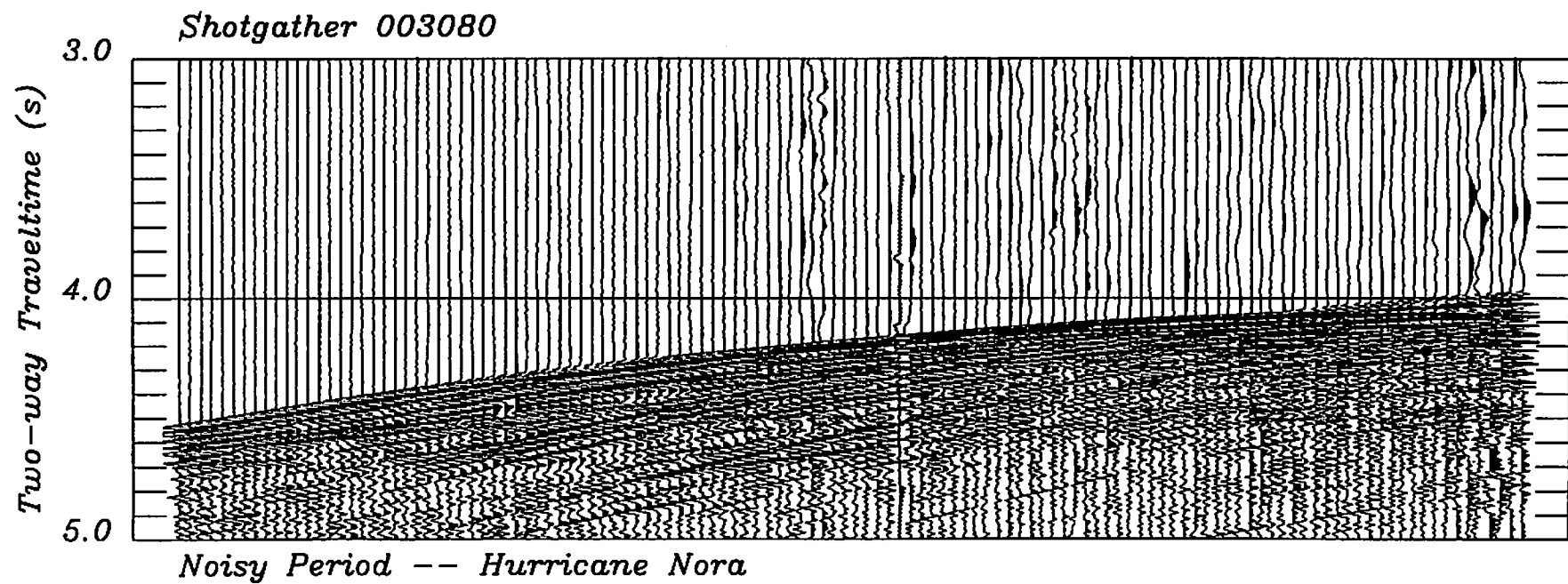
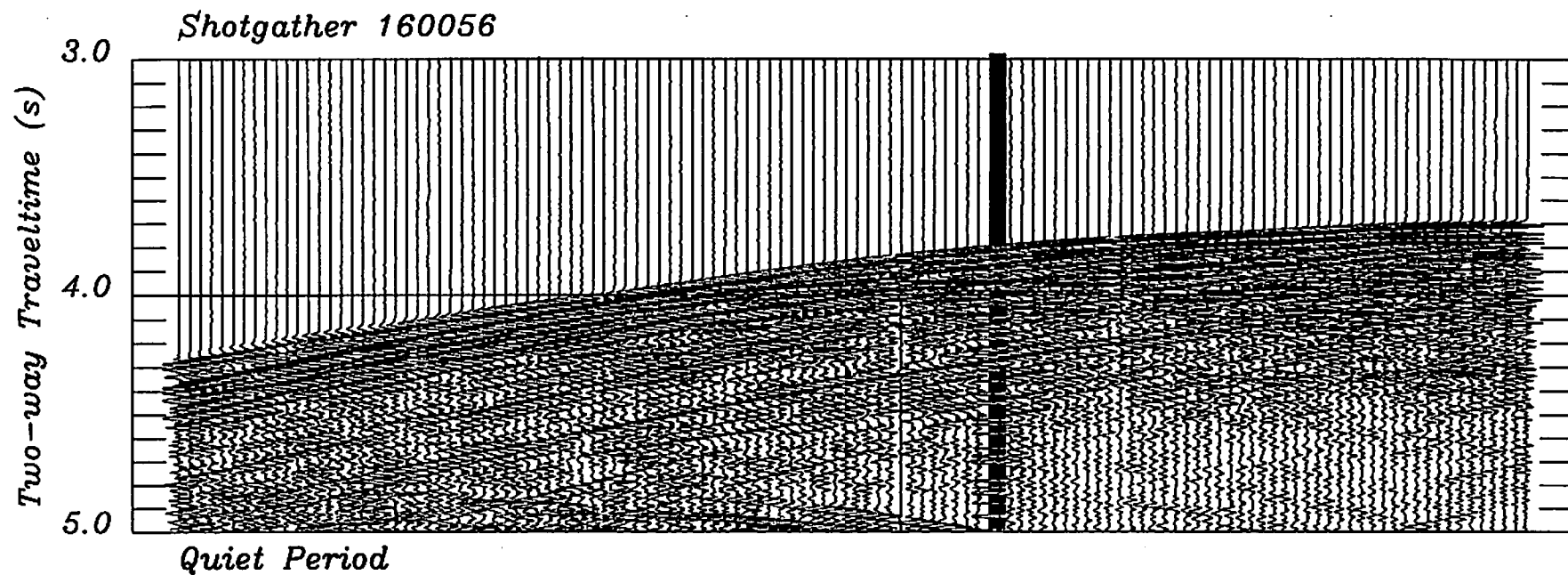
Aside from a few "noisy" days, the only other critical problem arose after shot #103970, when the A/D for every other sample started dropping the most significant bit; this resulted in a very ragged waveform, and a serious problem if one were to use an anti-aliasing filter before resampling. The IGPP investigators were dropping every other sample (fortunately the bad sample was being booted), and accepting some aliasing in the 60-90 Hz band, while the Cambridge scientists were looking into filtering before resampling (strictly the best way to resample)—but were side-tracked by the A/D (see Figures A1-4). It was agreed to drop the bad samples (every other sample), and accept some aliasing (whose frequencies are too high to be imaged properly during migration). If need be, the "sticky" bit could have been corrected through software (with alot of work), but the gain in useful fidelity would have been negligible. Of note, the DMS-2000 system was junked shortly after the ARAD cruise and replaced by a new Syntron DAS & 6 km streamer—although Nathan Bang's Barbados cruise might have been affected by this problem as well.



Final ARAD Reflection Bin Map









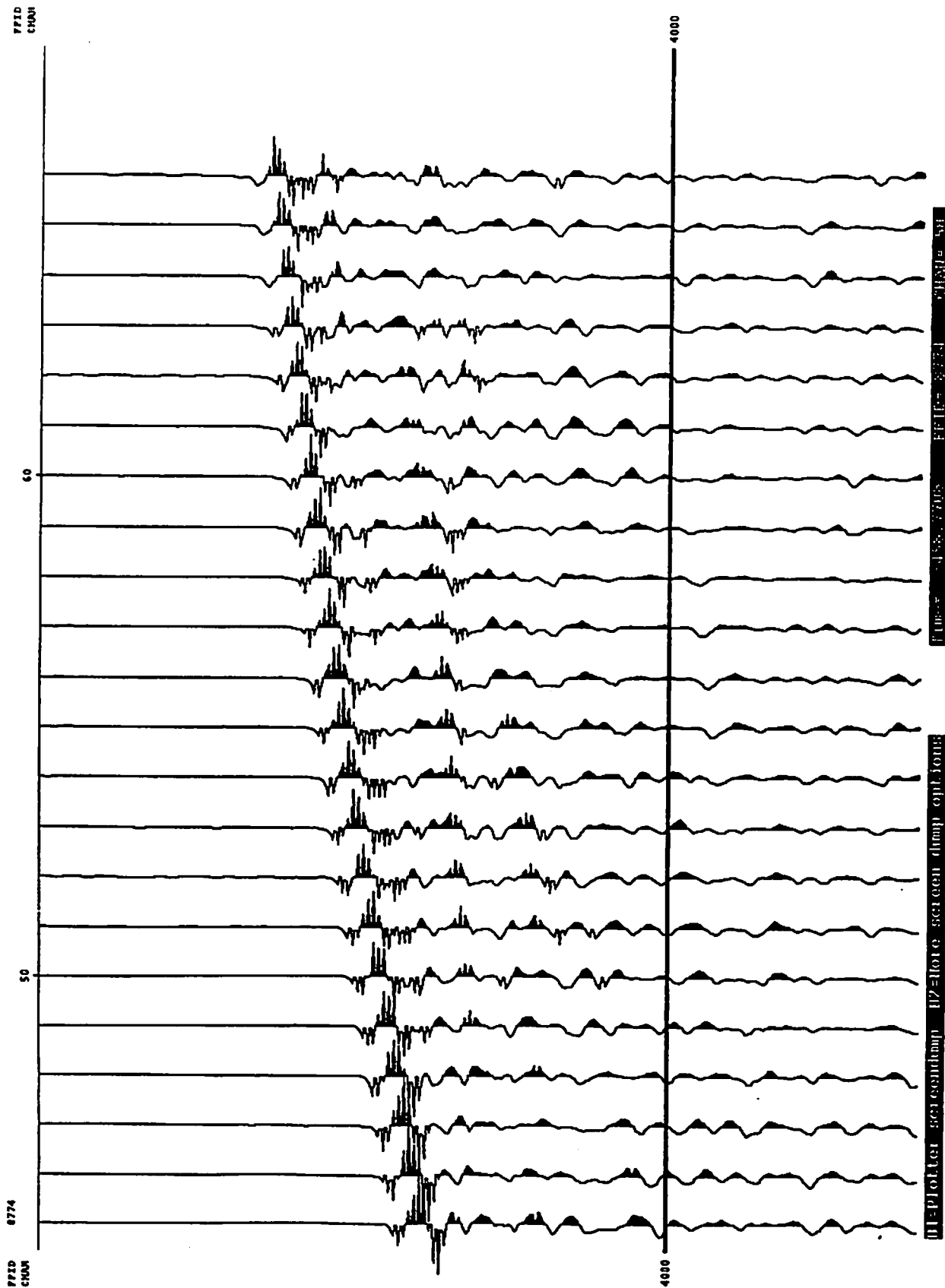
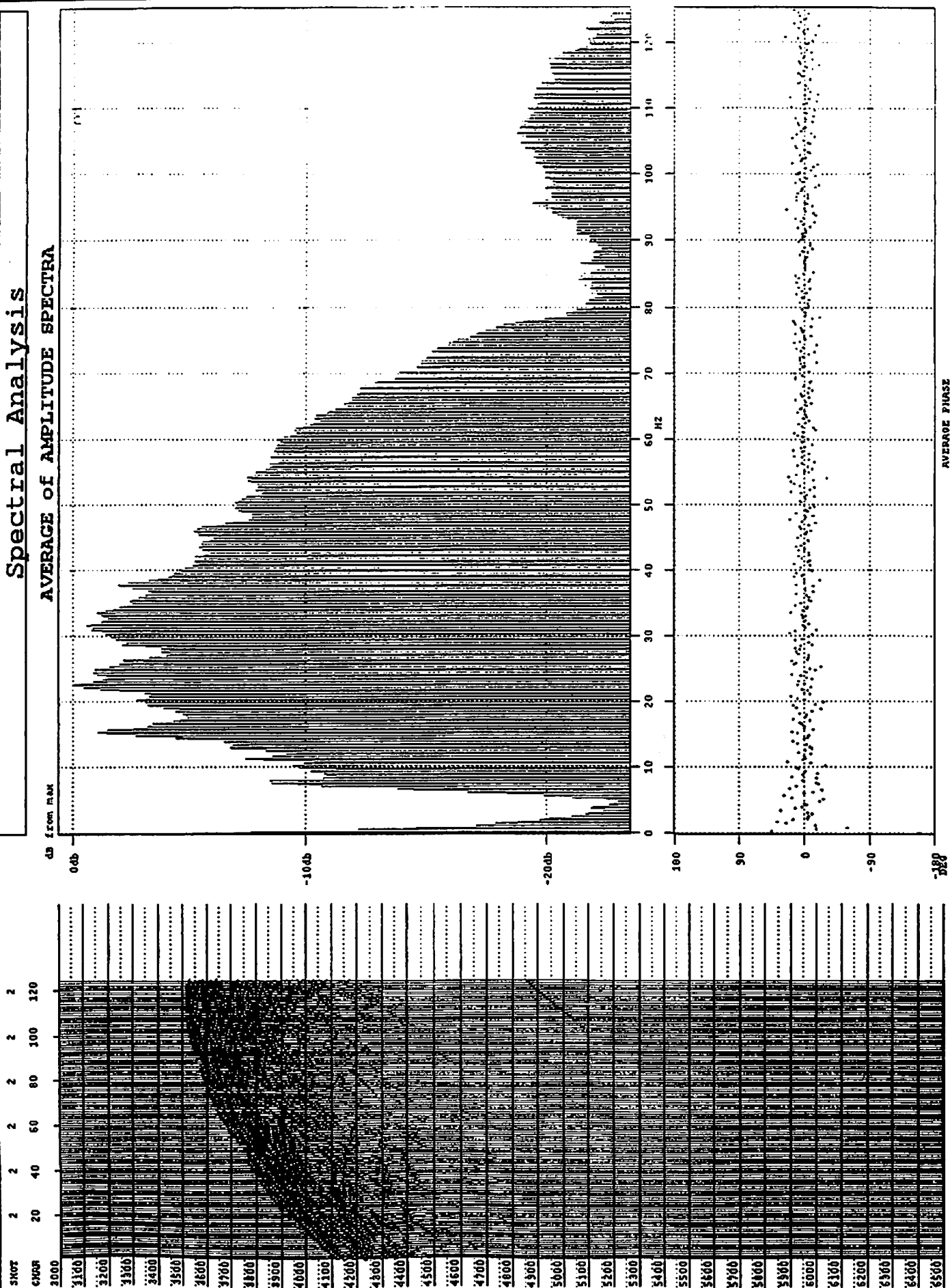


Figure A1 Raw seismic data with problems in the recording system recorded at 2 ms interval. The alternate samples for the large amplitude part of the data have zero exponent and hence their amplitudes are close to zero.





**FigureA2** Raw shot gather with problems in the recording system but re-sampled at 4 ms without any anti-alias filter, its amplitude and phase spectra. Since every even samples have been kept, there is no loss of energy up to 125 Hz.



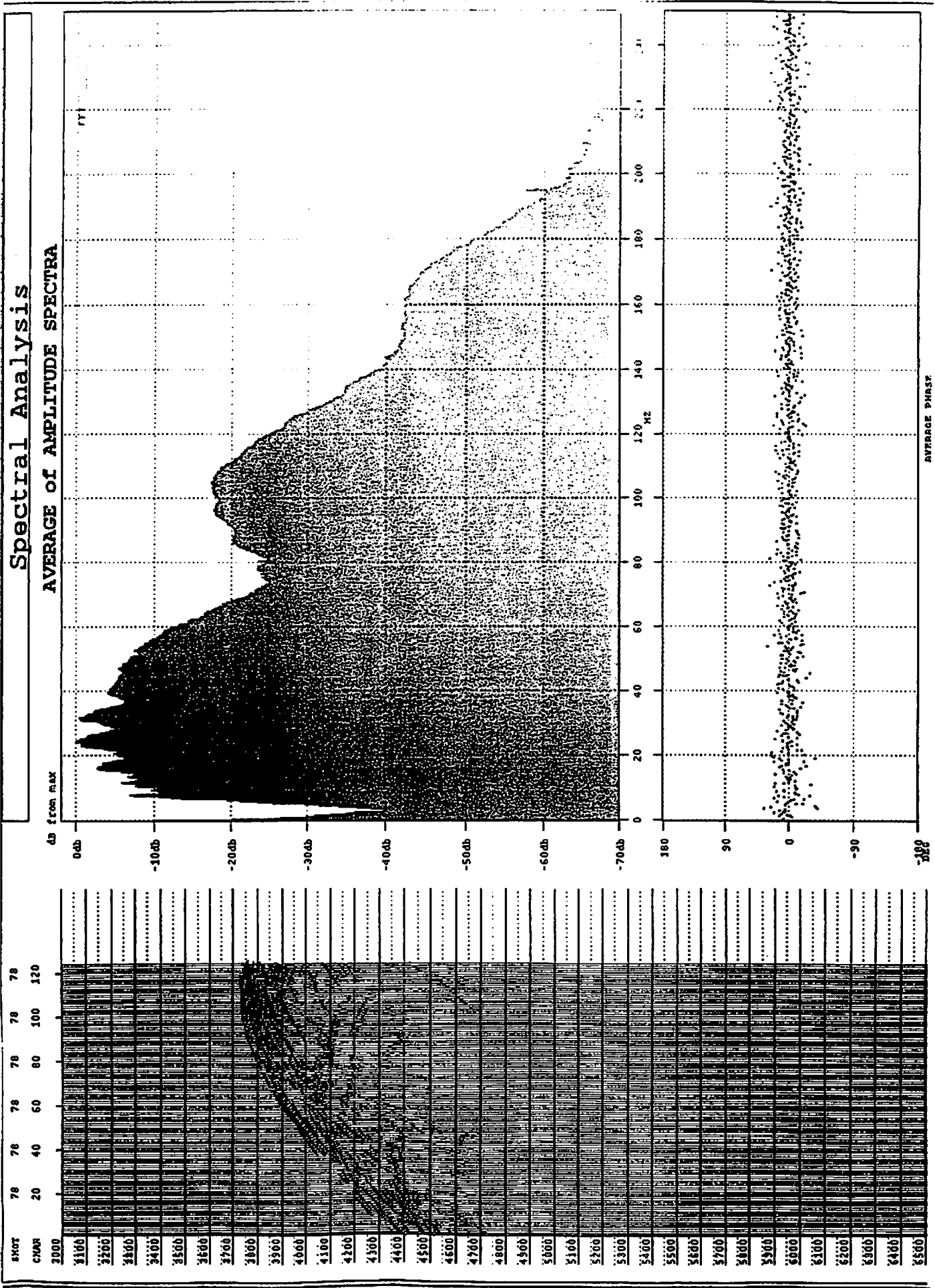


Figure A3 Raw shot gather without any problems in the recording system sampled at 2 ms, its amplitude and phase spectra. The energy in the data above the noise level (-30 dB) is up to 120 Hz.



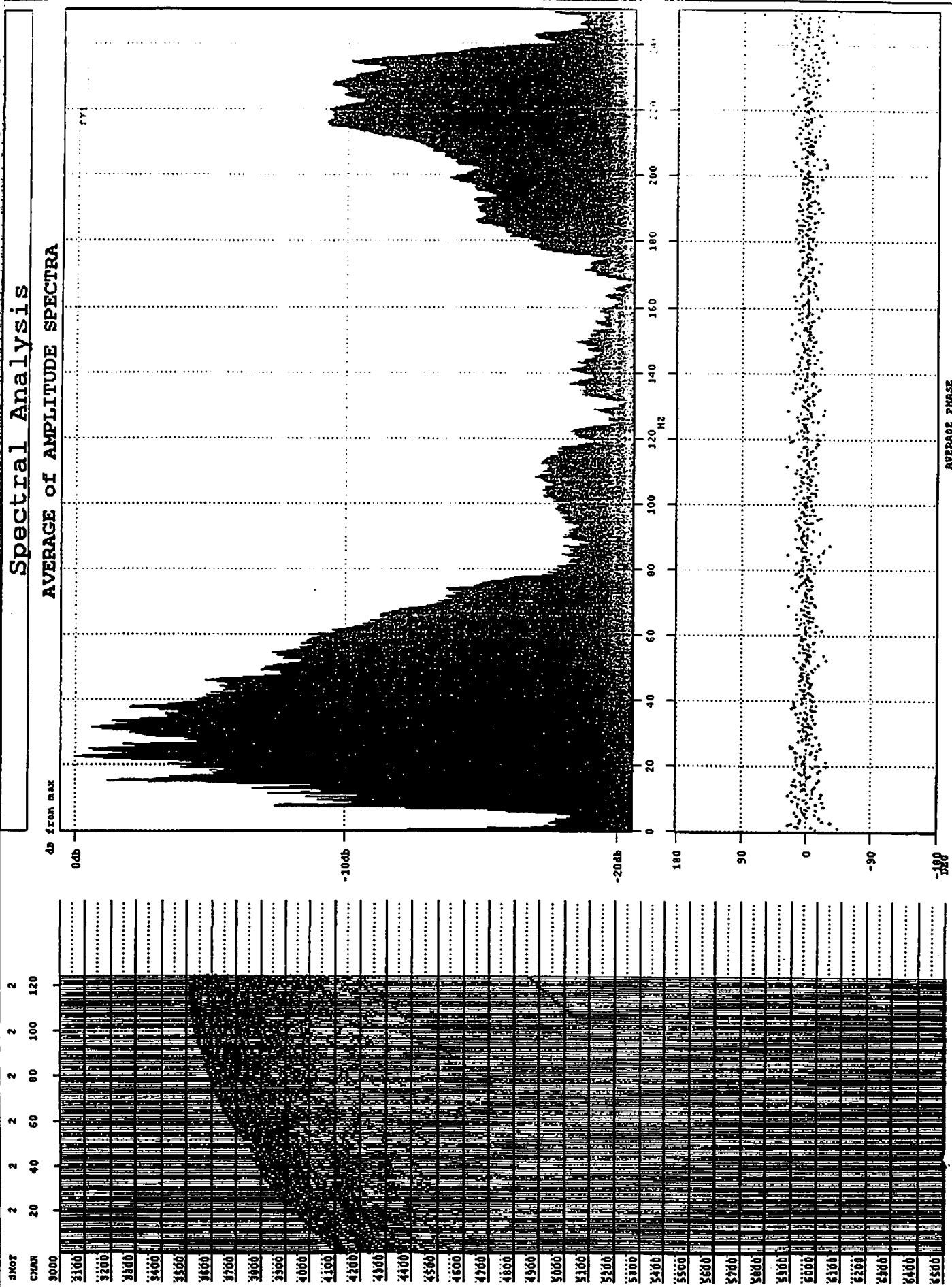


Figure A4 Raw shot gather with problems in the recording system recorded at 2 ms, its amplitude and phase spectra. Because of the exponent of every other samples were set to zero during the recording, the amplitude spectra has a peak at about 220 Hz.



Sail line #011 was used to investigate data quality, and is shown after migration (*Figure ARAD MCS Line 011, 45 Degree F-D Migration*). Near the rise-axis, images of both layer 2A and the axial magma chamber reflector (AMC) were imaged; unlike the 1985 MCS dataset, the additional offset (500+ m) has allowed more robust imaging of layer 2A reflections near the OSC. Images of Moho reflections were also captured within the NW and SE quadrants of the 3-D grid, although most of these events are patchy in character (*Figure Subline 190: Patchy Moho Reflections*). Migrated profile (#011) was also reprocessed with differing fold and range-gates to investigate the effect of uneven coverage within the 3-D image volume (*Figures ARAD MCS Line 011, fold/ranges*). For an offset independent reduction in fold, it would appear that the seismic image is still robust after a 50% decrease (40 to 20) in fold, which suggests that our final bin coverage is more than adequate (although some bin-extension will be required to fix those areas where fold reduction is range dependent). The range-gated stacks clearly show layer 2A reflections originating from the back-half of the streamer (> 1500 m); most interesting, however, is the offset character of the melt sill—this pattern may result from changes in crystal content within the melt or mush sill. This simple comparison suggests a wealth of amplitude variation with offset (AVO) information contained within the ARAD dataset.

#### IGPP/SIO OBH Operations and Data Quality

As mentioned earlier, most of the OBH shooting took place in rather unfavorable seas (beginning of cruise), since 3-D MCS operations were being compromised; nonetheless, of those profiles collected—L, MN, N, P, K, J, I, F, M, A, B, and C—only the suspended instrument *Godzilla* seemed to be adversely affected by the sea-state, and only for a few OBH profiles! During the OBH “shooting” phase, some 2000+ temporally less-frequent shots (110-120 s rep. rate) were fired (PmP & Pn events were seen to beyond 40 km in range for these shots); over the next 5 weeks, some additional 158,000+ MCS shots were recorded by the on-bottom array. These densely sampled events will provide an unprecedented coverage of layer 2 (< 1-2 km depth), providing a potential 75,000 source-receiver pairs per instrument, or some 1+ million traces combined. Localized stacking of the OBH/S data volume may also extend the 10 km cut-off range to beyond 15 km for those instruments positioned near the edge of the MCS grid. Nevertheless, the densified OBH/S picks should provide tight constraints on upper crustal velocities and anisotropy throughout the survey area; these data will also provide a clearer window into the processes which form the lower crust.

Lcheapo operations went smoothly with sets of 7 instruments deployed per working shift (2 shifts total). The acoustics were disabled after all 14 OBHs were grounded on the seafloor. Upon recovery, 10 of 14 instruments released within the expected 20-30 minutes after the initiation of the burn; 4 pesky instruments, however, took nearly 45 minutes each to release—this occurrence was partially responsible for changing our release system (Crispin Hollinshead has developed and tested a burn-wire, mechanical release system which releases in just a few minutes!). We did not encounter any acoustics problems in regards to ship-to-instrument communication. We did place our ‘ducer the fresh water well, beneath the science lab—which seemed to work out wonderfully. The 3-ball Lcheapos ascended through the water column at about 1/2 to 2/3 m per second, while the 4-ball version lifted-off at about 1 m per second—again given the cost of ship time, future experiments would benefit from having the extra float (\$300 ea.). Nonetheless, the Lcheapos performed flawlessly, collecting every byte of data requested (Appendix 6); time-drift from the Sea-Scan clock was in all but one case (Appendix 6) extraordinary, and the data quality was excellent. The suspended OBH *Godzilla* (1 km above seafloor +/-) was somewhat noisy during rough weather conditions, but on the whole performed nicely. Sara Bazin relocated all Lcheapo instruments, and her results are found in Appendix 8. We also took advantage of close instrument spacing to “test” the notion of a multi-ship (Ewing



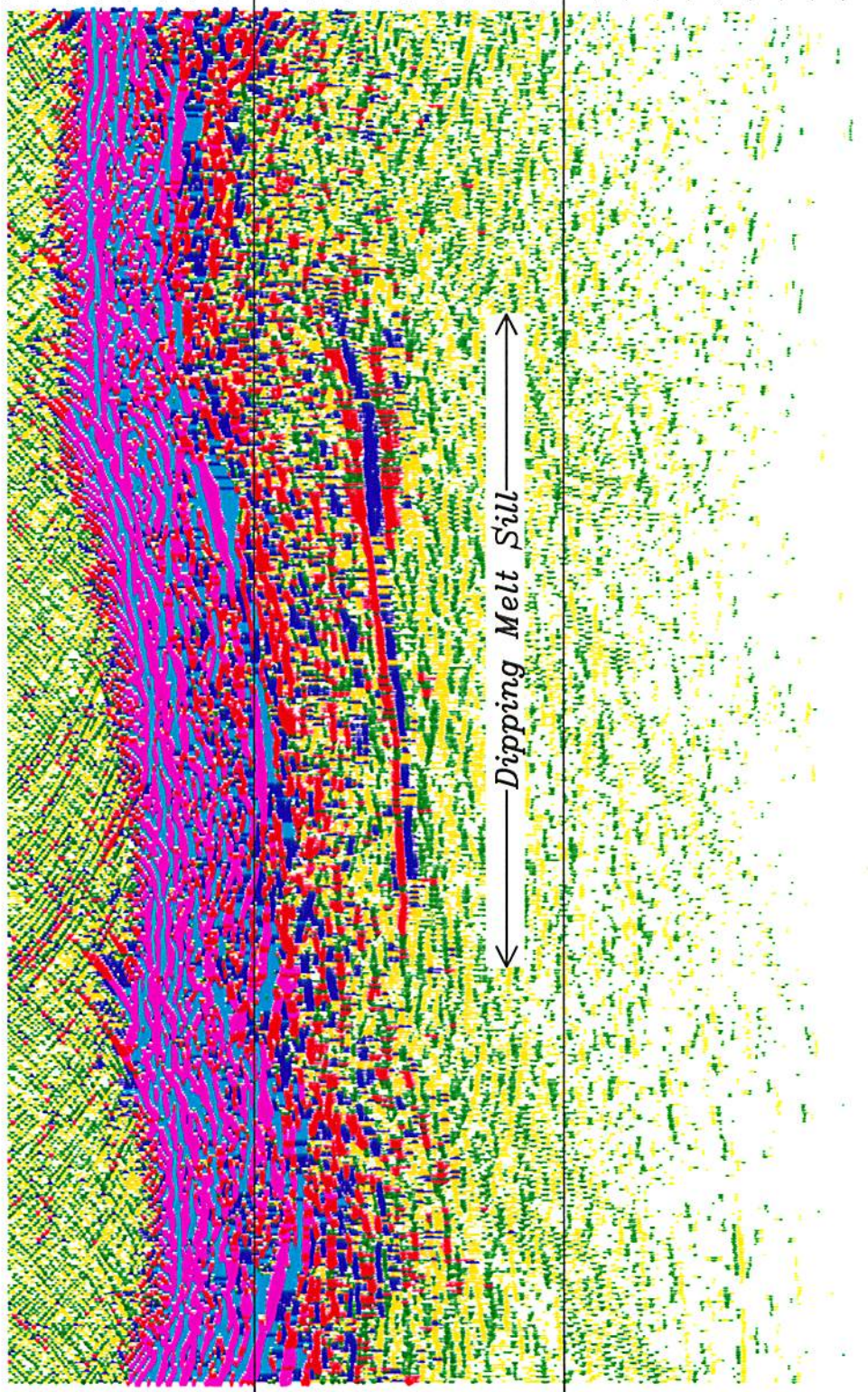
ARAD MCS Line 011

60700 60710 60720 60730 60740 60750 60760 60770 60780 60790 60800 60810 60820 60830 60840 60850 60860 60870 60880 60890 60900 60910 60920 60930 60940 60950 60960 60970 60980 60990 61000 61010 61020 61030 61040 61050 61060 61070 61080 61090 61100 61110 61120 61130 61140 61150 61160 61170 61180 61190 61200

3.0

Two-way Traveltime (s)  
4.0  
5.0

6.0



45 Degree Finite Difference Migration

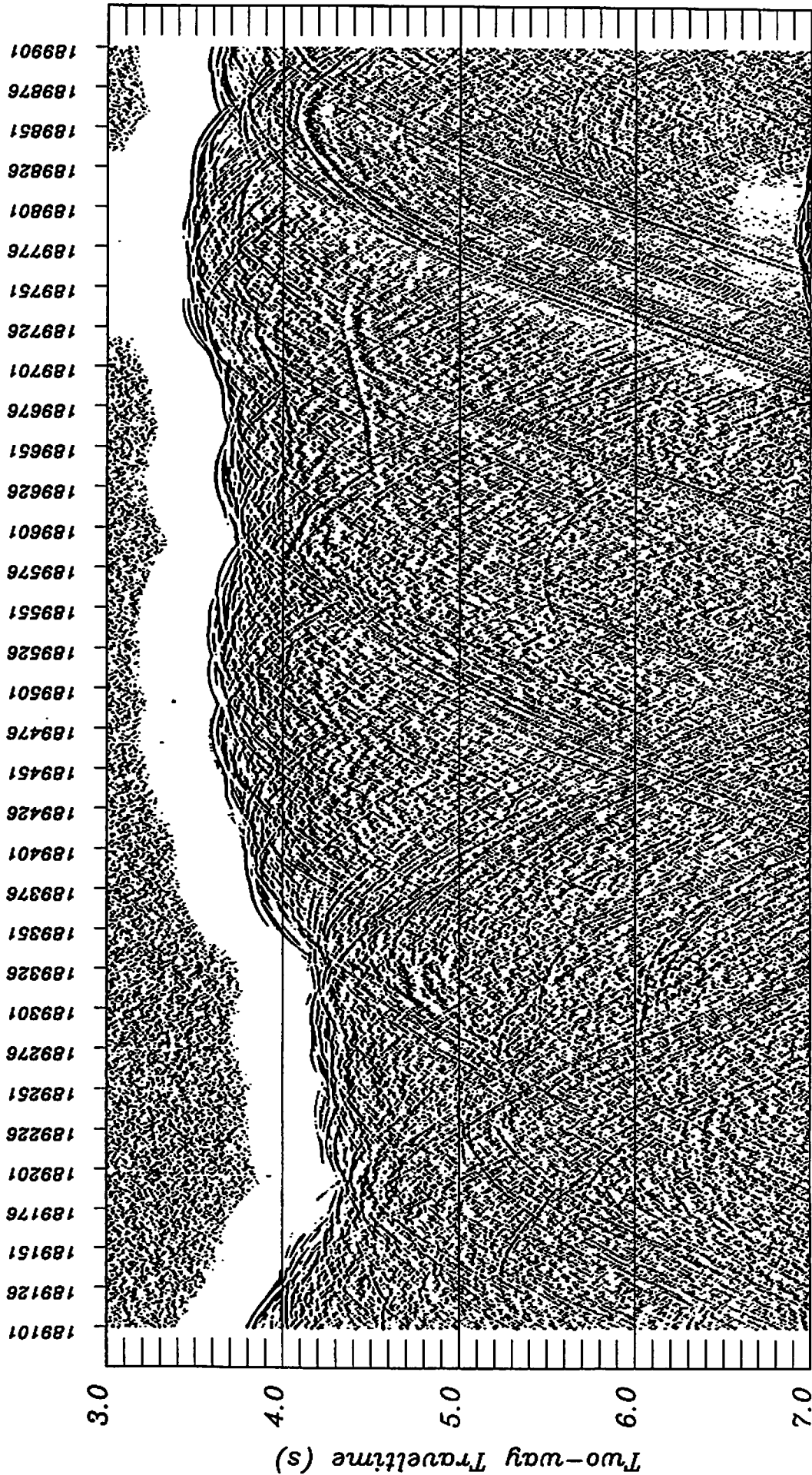
12.5 m bin, 40 fold







ARAD F SubLine 190 (Saline #012)

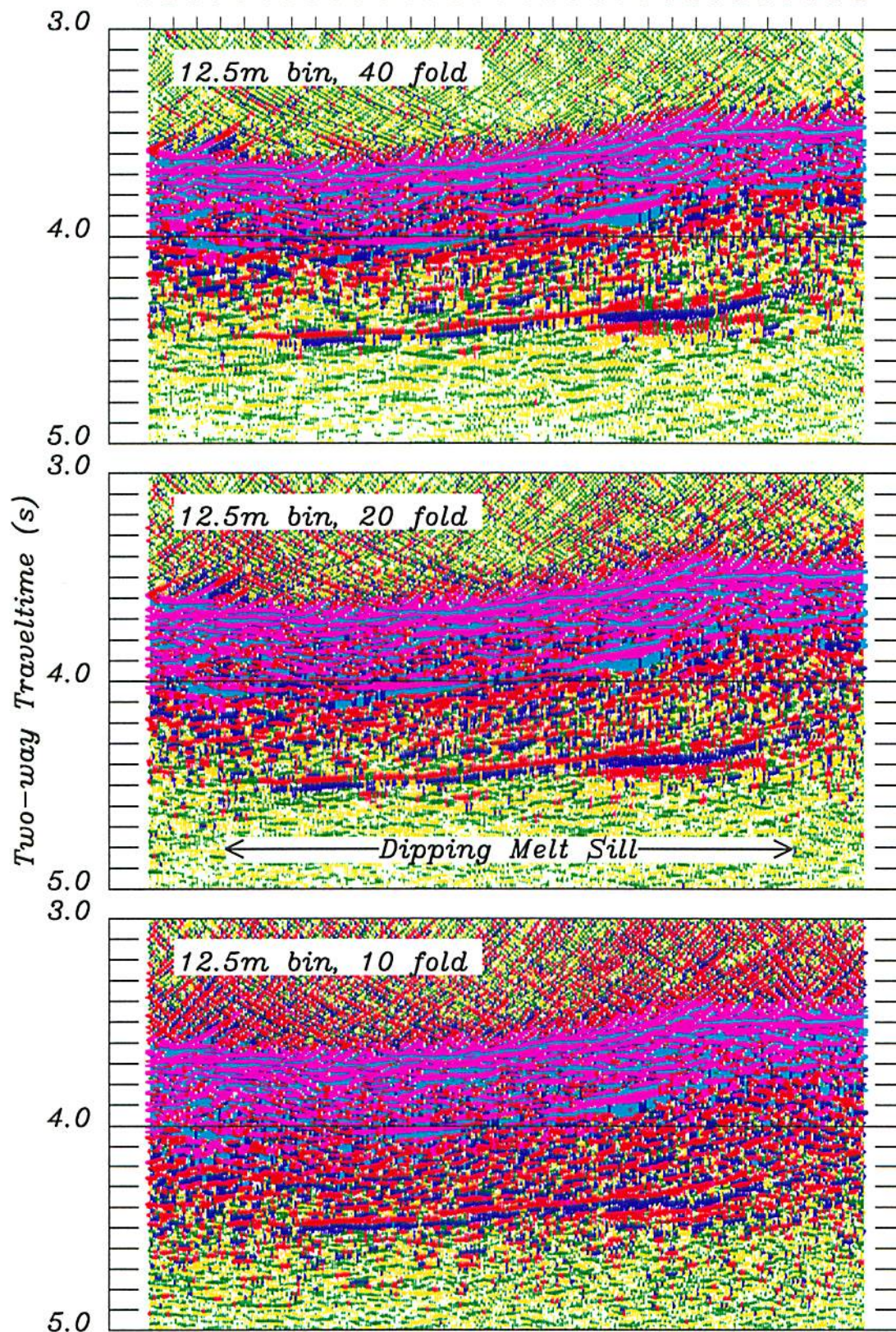


Final Brute Stack: Patchy Moho Reflections

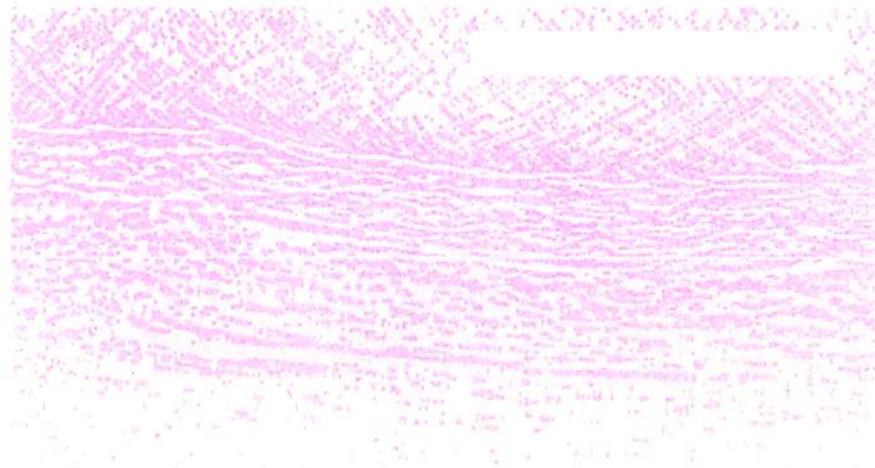
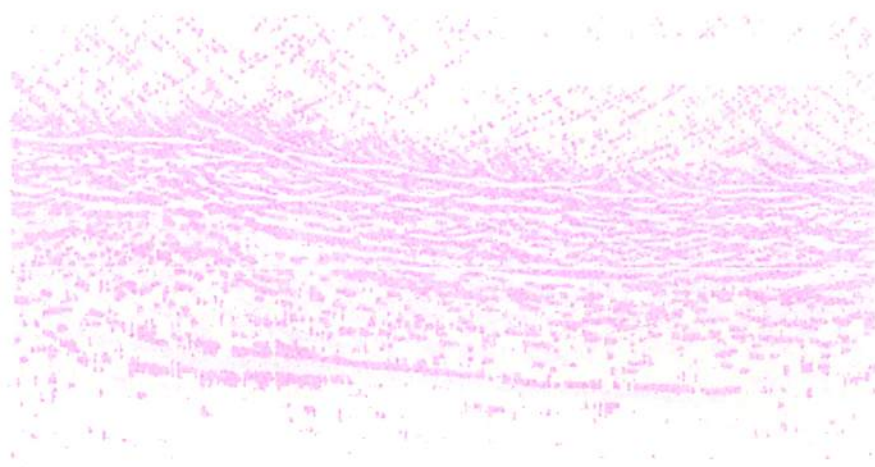


# ARAD MCS Sail Line 011

60820 60830 60840 60850 60860 60870 60880 60890 60900 60910 60920 60930 60940 60950 60960 60970 60980 60990 61000 61010 61020 61030 61040 61050 61060 61070 61080 61090 61100 61120



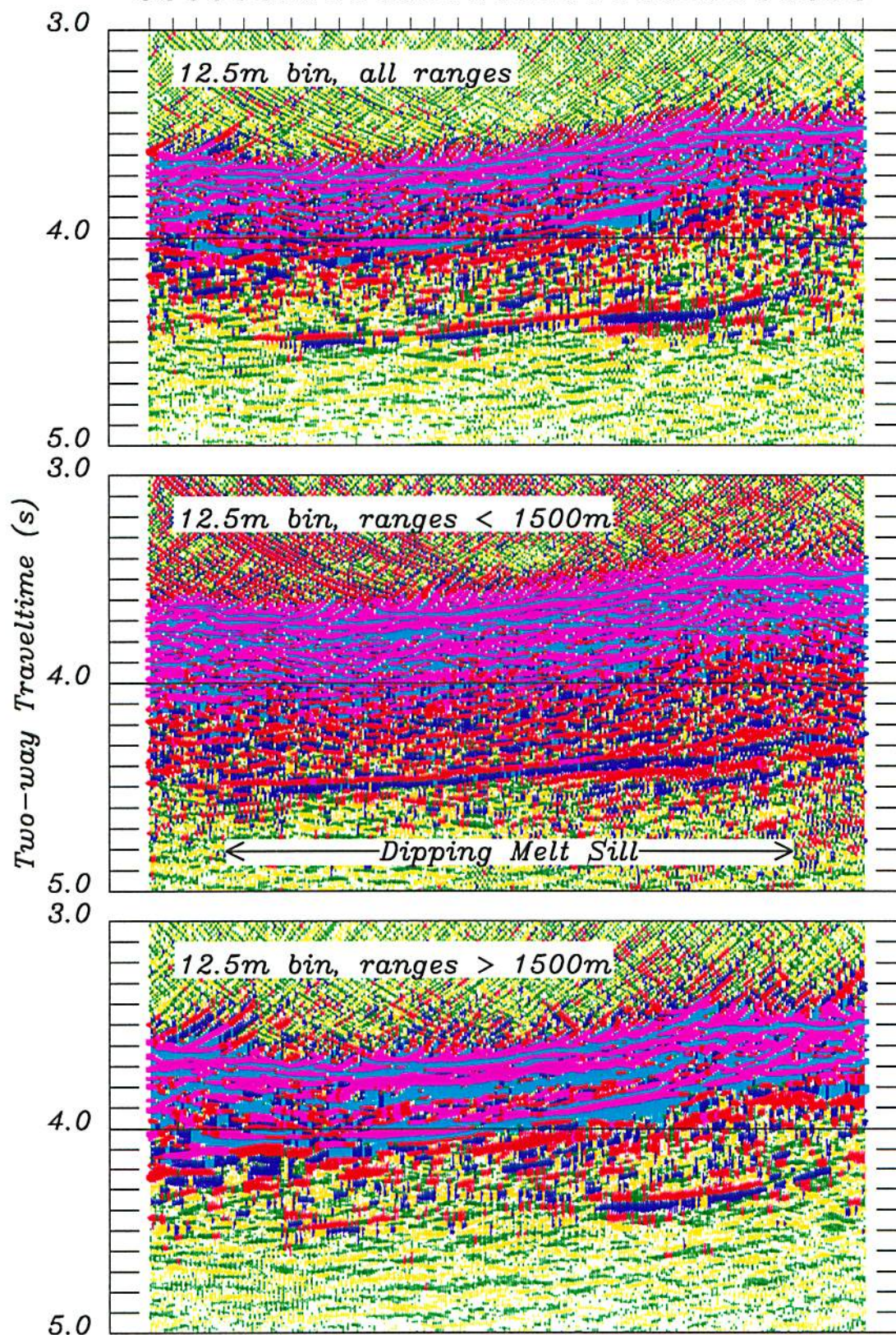




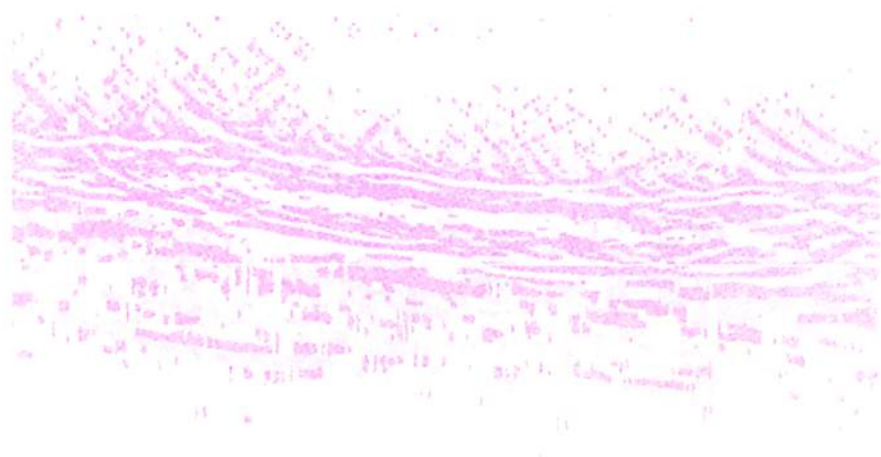
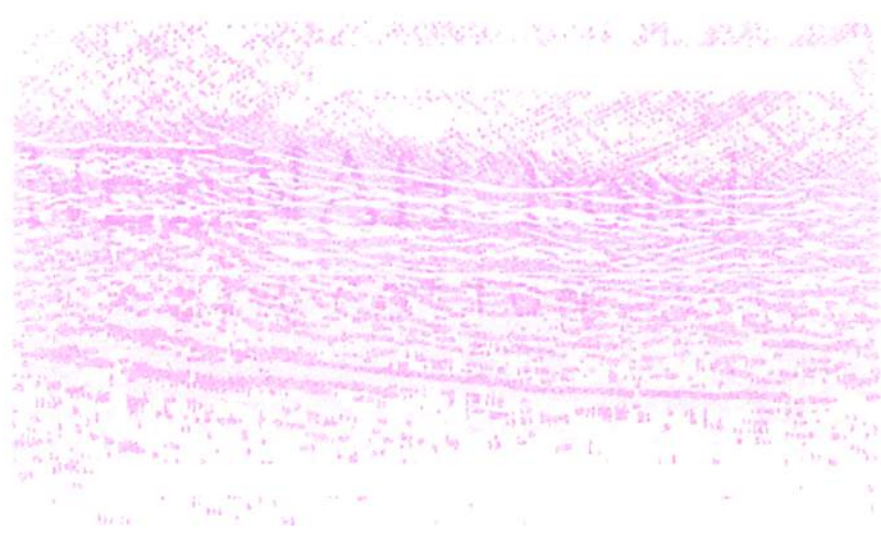


# ARAD MCS Sail Line 011

60820 60830 60840 60850 60860 60870 60880 60890 60900 60910 60920 60930 60940 60950 60960 60970 60980 60990 61000 61010 61020 61030 61040 61050 61060 61070 61080 61090 61100 61110 61120







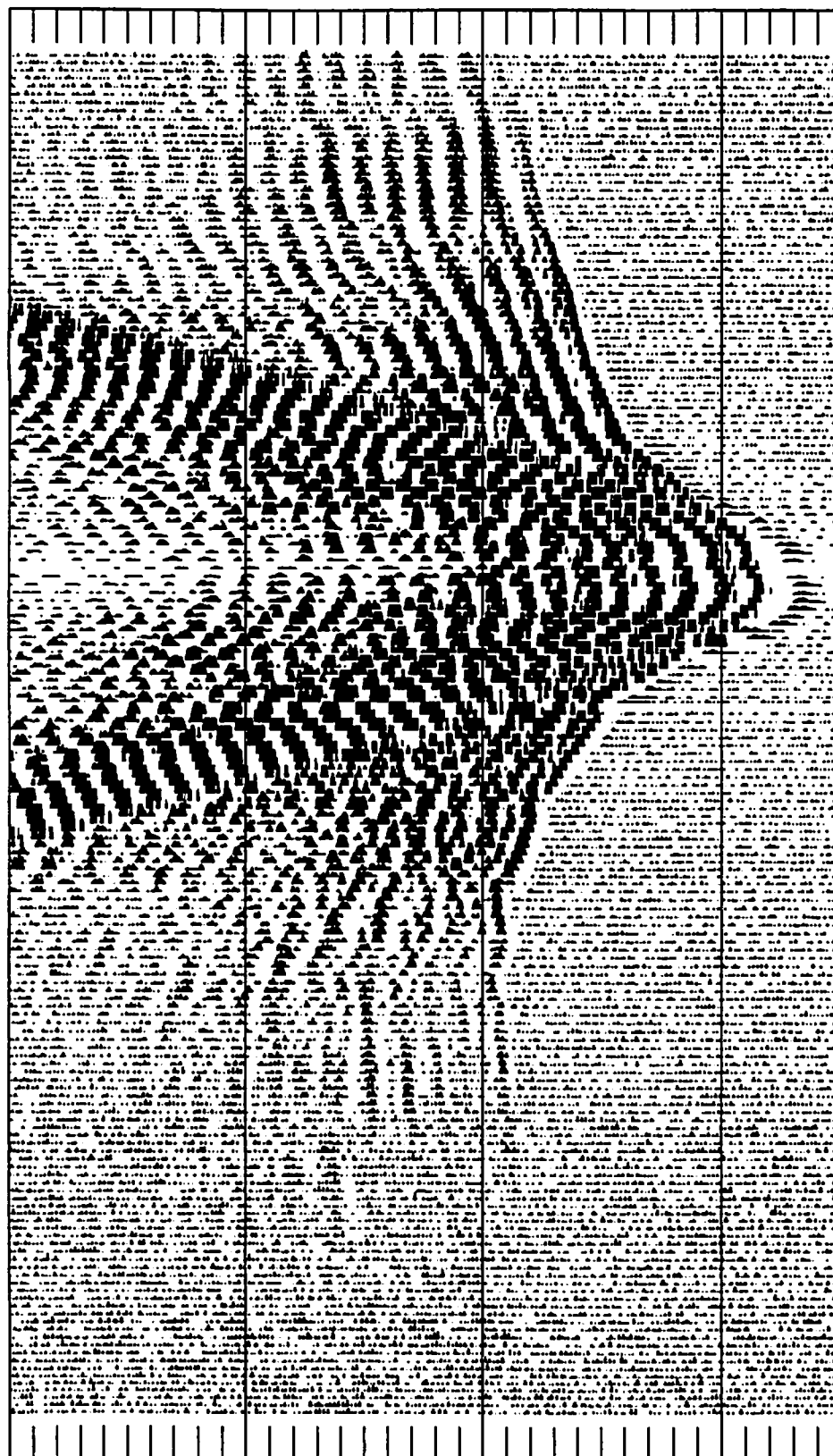


and workboat) recovery scheme (Thanks Captain). Mark (2nd mate), Alistair, and Paul Z. recovered a number of instruments independently, while the Ewing was bringing up the next in line. At times, the boat was > 5 km away (although in radio contact), but no problems were encountered—in the end, this strategy helped, in part, to recover 29 instruments in 50 hours, good job!

A representative OBH record section for instrument *Megalon* is shown in *Figure Megalon*: OBH Line F; this receiver-gather was shot along the longitudinal axis of the overlap basin, and highlights the presence of a low-velocity zone beneath this feature. *Figure Gamera*: OBH Line N shows arrivals crossing the overlapper, and highlights PmP arrivals reflecting beneath the basin. The “MCS” shots are also clearly visible, although the ~16 s repetition-rate produces a significantly noisier environment, which limits the maximum recorded offset to ~10 km (*Figure Lcheapo Megalon*: MCS Sail Line #040). These “extra” events will provide an unprecedented coverage of layer 2 (< 1-2 km depth), providing a potential 75,000 source-receiver pairs per instrument, or some 1+ million traces combined. These record sections can be combined to form a true record volume, to enable a complete recording of the seismic wavefield out to ranges beyond 10 km (see next section).



Megalon: OBH Line F



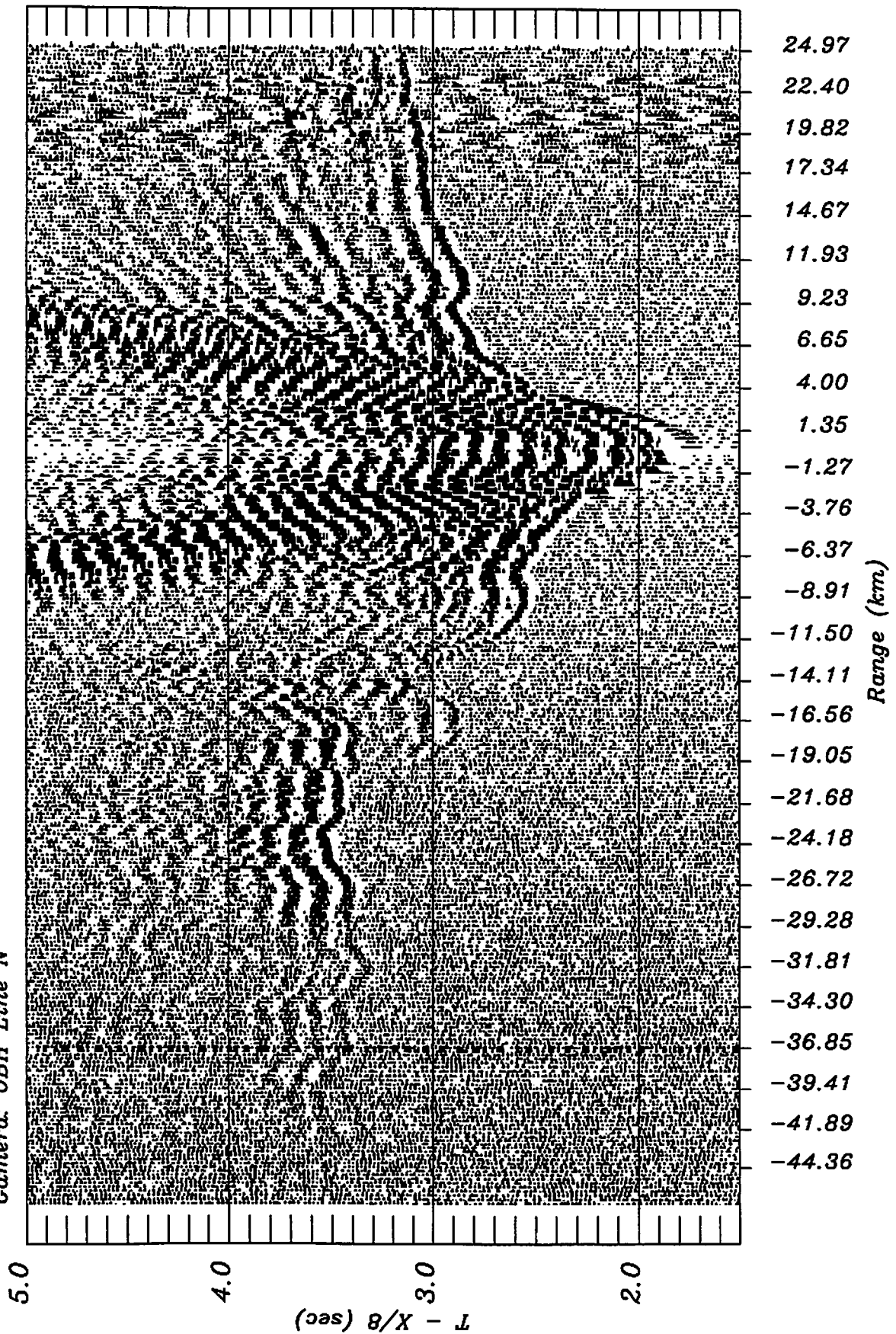
16.38  
13.83  
11.35  
8.81  
6.38  
3.97  
1.55  
-1.00  
-3.32  
-5.84  
-8.34  
-10.81  
-13.44  
-16.02  
-18.56  
-21.02  
-23.57  
-26.07

Range (km)

(sec) 8/X - L

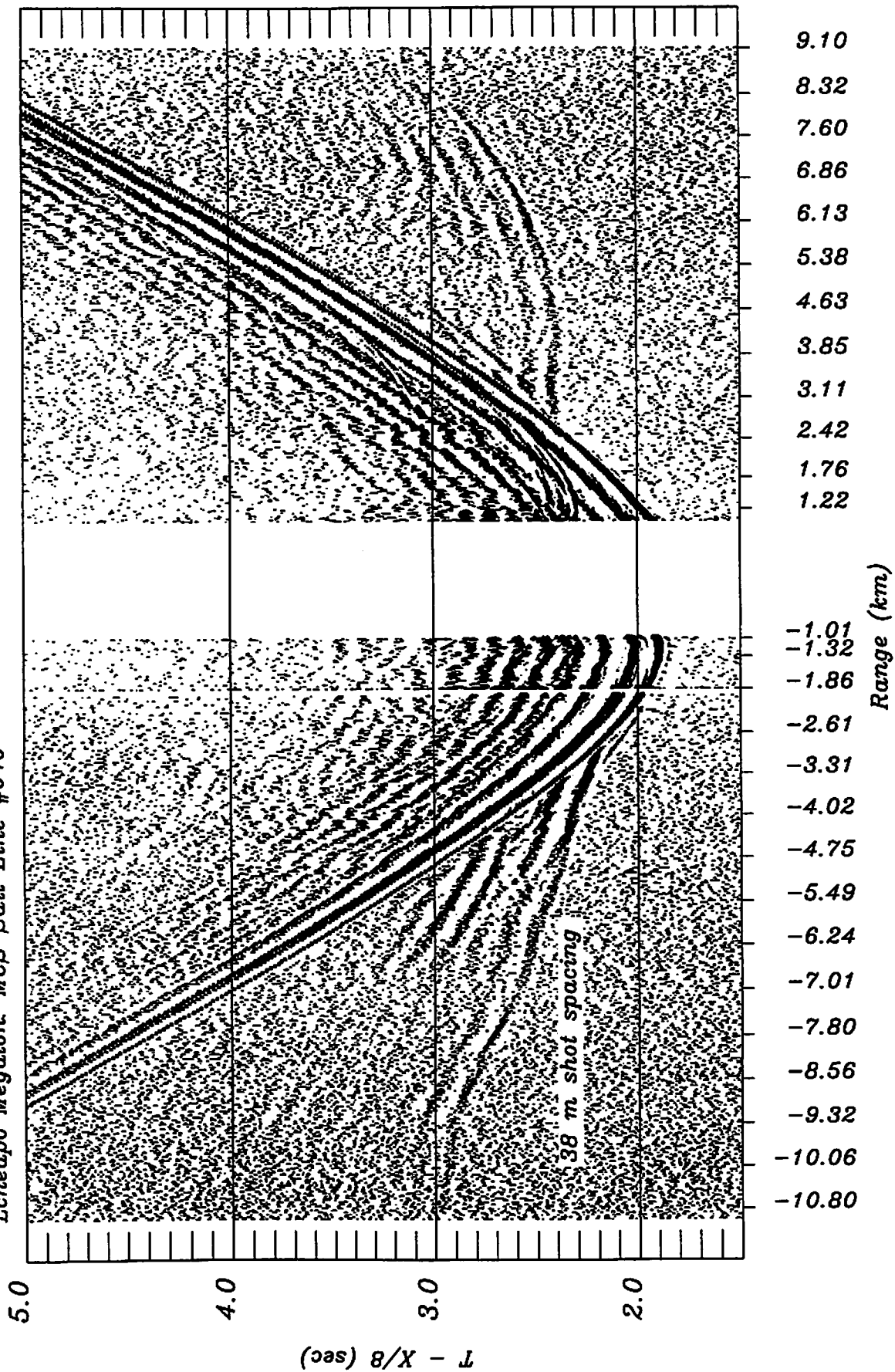


Camera: OBH Line N





Lcheapo Megalon: MCS Sail Line #040





## **Cambridge miniDOBS Operations and Data Quality**

Sixteen Cambridge ocean-bottom seismic recorders were deployed for the duration of the experiment (Table 1—Appendix 3). One instrument was lost, and fifteen were recovered. Of these, one suffered from a pressure case leak, and four failed to record data due to internal instrumentation problems. Eleven Cambridge instruments recorded high quality data from the experiment.

### **1.1 Cambridge Mini-DOBS System: technical summary**

All sixteen instruments were of the 'Mini-DOBS' type. The instrument is housed in a 432 mm (17") diameter spherical glass pressure case, which also provides buoyancy. The recording system uses 24-bit analogue to digital conversion, together with digital anti-alias filtering by a dedicated digital signal processing chip. The data are compressed before being recorded on a 2.1 Gigabyte SCSI hard disk drive. For this experiment, a second glass sphere housing was added to each instrument to provide additional battery capacity for the long (35 day) continuous recording period required.

We deployed 11 of the mini-DOBS as hydrophone-only instruments, with single channel recording systems and external hydrophone sensors. All of these OBHs were deployed as tethered instruments floating a short distance above a bottom weight. The other five mini-DOBS were all 4-component instruments, fitted with an external hydrophone and a three-component geophone package. Of these OBSs, four were fitted with external deployed geophone packages, and one had an internal geophone package. The geophones used all have a 4.5 Hz natural period, and each package has one vertical and two orthogonal horizontal geophones. The OBSs were deployed with rigid steel bottom weights, to which the instruments were attached by spring loaded burn wire release systems. On all OBH deployments, the data sampling rate was 256 Hz on a single channel; while for the OBSs, the data sampling rate was 128 Hz on each of four channels.

On some instruments, an internal acoustic release card manufactured by either Oceano (Mors) or by Marine Acoustics was used to actuate a burn wire release for recovery. However there were insufficient of these release systems available for all the instruments, and so some of the OBHs were deployed on longer vertical moorings with self-contained, external Oceano acoustic release units (model RT 661) placed in the mooring between the instrument and the bottom weight.

For the long rig OBH instruments, the height of the hydrophone sensor above the sea floor during data collection was 16 metres. For the OBSs, the external geophones were sited directly on the sea floor; the internal geophone package 0.3 metres above the sea floor; and the hydrophones 0.45 m above the sea floor. Two OBHs (Instruments 28 and 32) were deployed with 'short' but tethered deployment rigs. For these, the height of the hydrophone above the sea floor was 1.5 m.

### **1.2 OBS Deployments**

All 16 Cambridge instruments were deployed without difficulty during three periods totaling 16 hours (1100Z/257 to 1430Z/257 [2 instruments]; 0130Z/258 to 0720Z/258 [7 instruments]; and 1800Z/258 to 0045Z/259 [7 instruments]). The first two (instruments 31 and 33) were monitored acoustically until they reached the sea floor; but the others were not. No problems were encountered during any of the deployments, except that the acoustic release system of instrument 32 (which was subsequently lost) failed to respond to interrogation after the instrument was launched. The acoustic transpond mode of the RT 661 units was disabled at launch on all instruments. Deployment locations and times are summarized in Table C\_OBS 1 (Appendix 3).



All instruments were deployed using the starboard side A frame and its small, hydraulic winch. This worked well for our purposes. The proximity of the CTD room (where the instruments were prepared) to the A frame was an advantage. We found that for some of the time we were able to communicate with the instruments on the sea floor, using the Oceano deck unit's dunking transducer in the transducer well beneath the main lab. However, at times the noise levels were too high to permit this and part of the problem was traced to the sewage pump in the engine room, which makes the hull acoustically noisy. Even with that pump off, it was necessary sometimes to use a separate, over-side dunking transducer to communicate with the instrument successfully. We therefore located one deck unit in the CTD lab, with a transducer rigged for over-side deployment beneath the starboard A frame; and a second deck unit in the main lab, with its transducer in the well.

### **1.3 OBS recoveries**

OBS recoveries were carried out over a series of time periods, totaling 26 hours, between 1800Z/293 and 0055Z/296. The recoveries were interleaved with periods for recovery of Scripps instruments. Fifteen instruments were recovered, but one (instrument 32) failed to respond to any acoustic signals; failed to surface within the expected time from receipt of the release signal; and was therefore lost. One further instrument (number 31) was recovered in a damaged state, with its battery sphere flooded.

Recoveries were carried out using the starboard side A frame, as for deployments. This was again convenient and straightforward. The same acoustic arrangements (one deck unit in the main lab, with transducer in the well; one deck unit in the CTD lab, with transducer rigged for overside use, beneath the starboard A frame) were used as for deployment. Under good conditions, it was possible to release OBSs from several kilometres horizontal range, but hull noise levels were variable, so that for other recoveries we had to stop close to the instrument and use the overside transducer.

### **1.4 OBS performance**

Eleven instruments recorded good quality data. Of those which did not, the most common problem was related to the disk drive interface, which on some instruments was unable to access the disk drives after the instruments were deployed. On the good instruments, the recorded data are compressed to an average of 11 bits per sample. Data quality is generally high, although there is a problem caused by cross-talk between the clock system and the seismic channels. This has the effect of putting a small but highly regular signal onto the seismic channels which coincides with instrument clock seconds. Initial post-cruise processing at Cambridge indicates that this contamination can be readily removed by summing the signal over a large number of seconds, and then subtracting the mean interfering wave form from each second of each seismic trace.

Instrument performance is summarized in Table C\_OBS 2 (Appendix 4), and is detailed below:

#### **Instrument 26:**

Deployed as a 4-component instrument with hydrophone and internal 3-component geophone. Recovered OK, but experienced disk drive access problems and failed to record any data.

#### **Instrument 27:**

Deployed as a 4-component instrument with hydrophone and external 3-component geophone. Recovered OK. Recorded data up to 0819Z/271, but no further data thereafter. Total recorded about 0.5 Gigabytes.



Instrument 28:

Deployed as a hydrophone-only instrument, on a short mooring with internal acoustic release. Recovered OK. Recorded throughout the experiment (1.3 Gigabytes).

Instrument 29:

Deployed as a 4-component instrument with hydrophone and external 3-component geophone. Recovered OK. Recorded data until its disk was full (2.1 Gigabytes), finishing on Day 287.

Instrument 30:

Deployed as a 4-component instrument with hydrophone and external 3-component geophone. Recovered OK. Recorded data until its disk was full (2.1 Gigabytes), finishing on Day 286.

Instrument 31:

Deployed as a 4-component instrument with hydrophone and external 3-component geophone. Recovered with its battery sphere flooded. No data had been recorded.

Instrument 32:

Deployed as a hydrophone-only instrument, on a short mooring with internal acoustic release. The release acoustics failed after deployment, and never responded to commands from the ship. The instrument was lost.

Instrument 33:

Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK, but experienced disk drive access problems and failed to record any data.

Instrument 34:

Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK, but experienced disk drive access problems and failed to record any data.

Instrument 35:

Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK. Recorded throughout the experiment (1.3 Gigabytes).

Instrument 36:

Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK. Recorded throughout the experiment (1.3 Gigabytes).

Instrument 37:

Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK. Recorded throughout the experiment (1.3 Gigabytes).

Instrument 38:

Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK. Recorded throughout the experiment (1.3 Gigabytes).

Instrument 39:

Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK. Recorded throughout the experiment (1.3 Gigabytes).

Instrument 40:



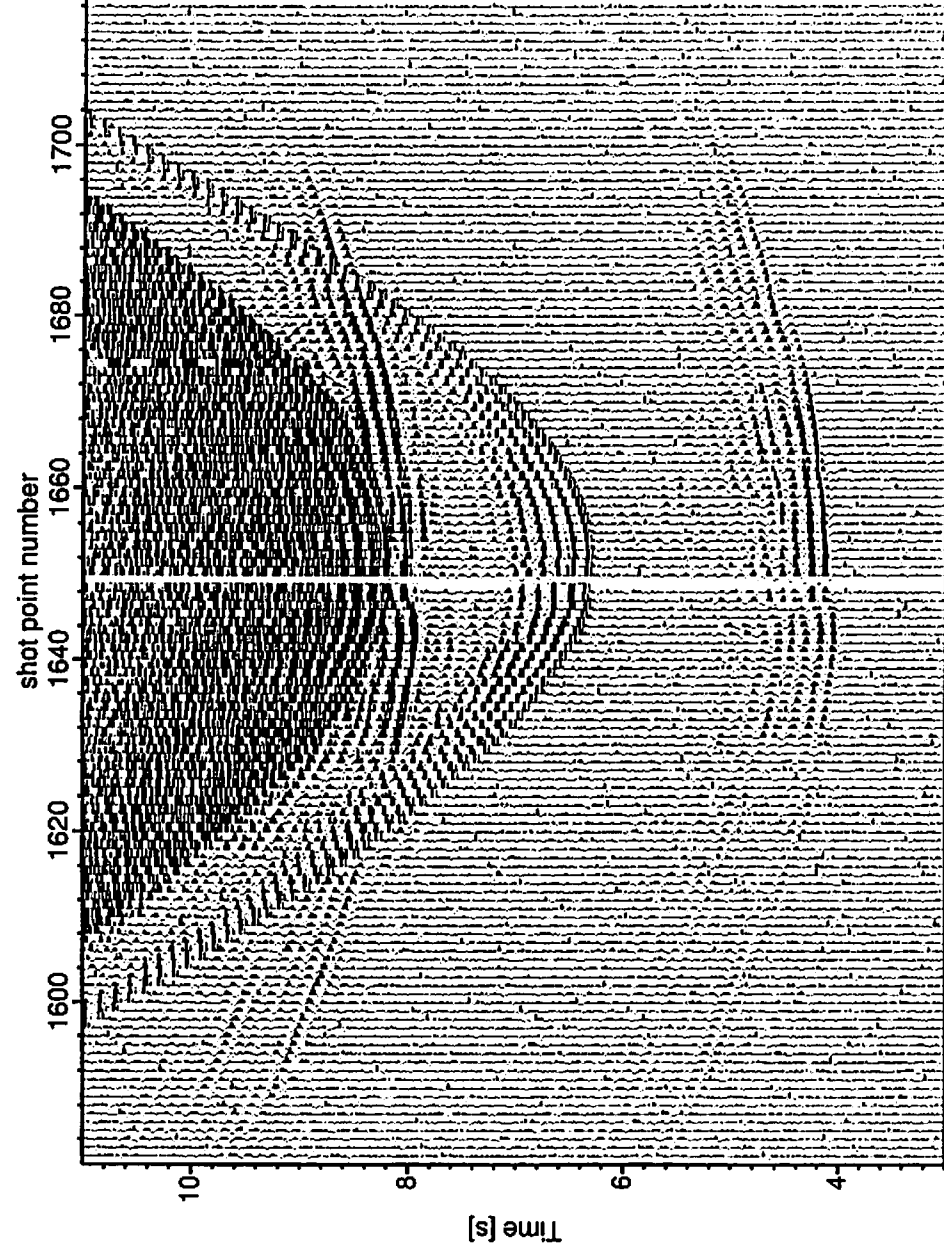
Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK. Recorded throughout the experiment (1.3 Gigabytes).

**Instrument 41:**

Deployed as a hydrophone-only instrument, on a long mooring with external RT-661 release. Recovered OK. Recorded throughout the experiment (1.3 Gigabytes).

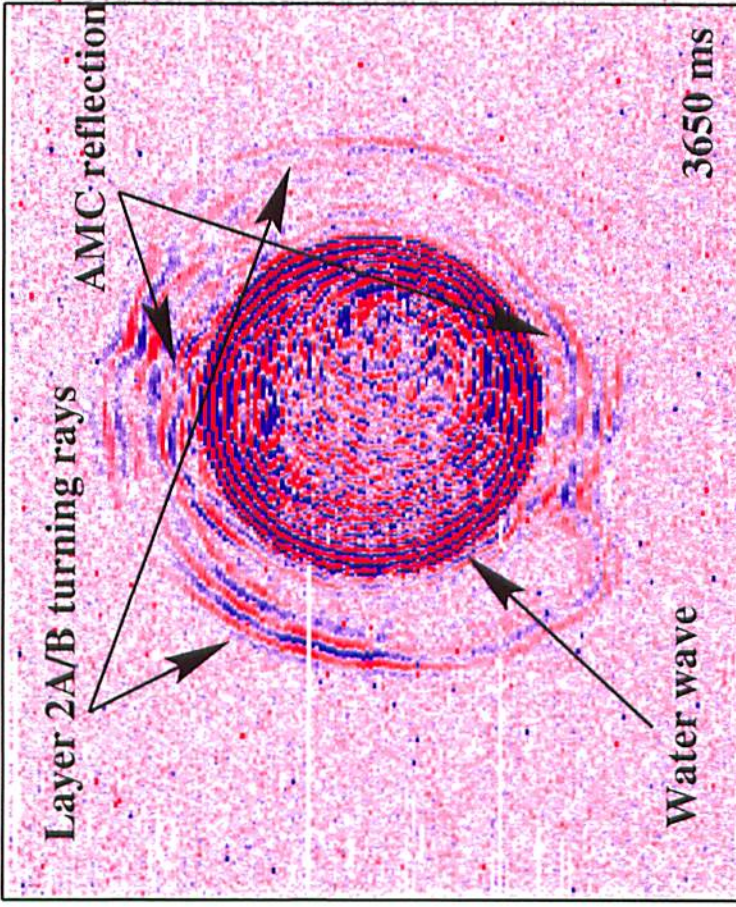
An example record section from miniDOBS OBS 39 SITE O12 is seen on the following page. Also, a true record volume time slice (OBS 38; 3650 ms) is shown to highlight the power of 3-D recording!





OBS39 SITE O12





OBS 38

OBS Record Volume



## Appendix 1

### Science Complement and Officer List

#### Science Complement

|                     |                      |                 |
|---------------------|----------------------|-----------------|
| Graham M. Kent      | Chief Scientist      | SIO/IGPP        |
| Alistair J. Harding | Co-Chief Scientist   | SIO/IGPP        |
| Satish Singh        | Co-Chief Scientist   | Cambridge/BIRPS |
| Martin Sinha        | Co-Chief Scientist   | Cambridge       |
| Joe Stennett        | Science Officer      | L-DEO           |
| Charles Donaldson   | Electronic Tech      | L-DEO           |
| John DiBernardo     | Pneumatic Engineer   | L-DEO           |
| Jeff Turmelle       | Computer System Mgr. | L-DEO           |
| Stefan Hussenoeder  | Graduate Student     | WHOI            |
| Harm Avendonk       | Graduate Student     | SIO/IGPP        |
| Crispin Hollinshead | OBS Engineer         | SIO/IGPP        |
| Paul Zimmer         | OBS Engineer         | SIO/IGPP        |
| Paul Henkart        | Geophysical Analyst  | SIO/IGPP        |
| Tim Owen            | miniDOBS Engineer    | Cambridge       |
| Dan Boschi          | miniDOBS Engineer    | Cambridge       |
| Adam Cherrett       | Graduate Student     | Cambridge       |
| Anthony Greer       | Graduate Student     | Cambridge       |
| Vincent Tong        | Graduate Student     | Cambridge       |

#### Officer list

|                     |                |
|---------------------|----------------|
| James E. O'Loughlin | Captain        |
| Louis J. Mello      | Chief Mate     |
| Mark Landow         | 2nd Mate       |
| Richard Thomas      | 3rd Mate       |
| Sport               | Chief Engineer |

#### ARAD PI's Ashore

|                |       |              |
|----------------|-------|--------------|
| John A. Orcutt | Co-PI | IGPP/Scripps |
| Penny Barton   | Co-PI | Cambridge    |
| Robert White   | Co-PI | Cambridge    |



## **Appendix 2**

### **General Comments from Cambridge PI's**

#### **1. Support from Lamont staff (officers, crew and science support)**

Throughout the cruise, the Cambridge science party received an excellent level of technical support from the vessel's officers and crew and the Lamont scientific staff. We thank all concerned both for their hard work and for their hospitality, which made the cruise a pleasant experience for all.

#### **2. Lab spaces and chairs**

One feature of the ship's scientific spaces is the atrocious state of the chairs provided for scientific use. Some of the existing chairs are merely so old that they are no longer comfortable. Some are entirely inappropriate (e.g. with swivelling back supports) for use at sea. A significant number are so badly broken that they are downright dangerous. Lamont should immediately throw out every single chair in every science space on the vessel, and replace them with suitably stable alternatives for use at sea. This will require at least 3 chairs in the science office; at least 10 chairs in the main lab; 3 in the analytical lab; 3 or 4 in the dry staging lab; and 3 in the CTD lab. No employer ashore would get away with providing such lamentable furniture in a work space, and no self respecting office worker would put up with it. There is no reason why scientists, who typically work very long hours at sea, should be expected to tolerate such poor provision.

#### **3. Airgun System**

The airgun array and its deployment system is undoubtedly the Ewing's most important and notable asset. The gun array functioned well throughout the cruise, despite significant sea states for much of the first month. The extremely high level of quality and reliability of this part of the acquisition system was a major factor in the success of the cruise, and Lamont's airgun team deserve special acknowledgment for their professionalism and hard work.

#### **4. Mobilization**

Mobilization in Panama proceeded very straightforwardly, assisted by the fact that our container had been loaded onto the ship in Lisbon well before the start of the cruise. No significant problems were experienced.

#### **5. Demobilization**

Demobilization in Manzanillo was far from straightforward. The major blame for this lies with the ship's agent, who failed consistently to deal competently with the Cambridge scientific party's requirements. These requirements were made known to him well in advance of our arrival in port, and were straightforward. We had a shipment of air freight which needed immediate transportation back to the UK; and a container which also needed shipping back to the UK. The agent had made no worthwhile preparations for either of these shipments when we arrived in Manzanillo. Thereafter he appeared to be incapable of making arrangements for sending them to anywhere but the US, where he expected us to appoint new agents to send them on to the UK. His suggestion for our air freight was that it should go in the Scripps container to San Diego, and that the Scripps science party should then unpack it for us, separate it from their equipment, and forward it to the UK. In the end, having done much of the leg work ourselves, we arranged to have the airfreight returned to the UK by DHL at an uncomfortably high cost.



At the time of writing (1 December) our container is still not back in the UK, since the agent insisted on sending it first to Long Beach (entirely the wrong direction) before onward shipment back to Europe. This seems astonishing given that Manzanillo has a large and busy container port. We are continuing to have to do a great deal of leg work and chasing up to try and get our container home – work that would have been unnecessary had the agent done his job competently. Sadly for him, no amount of back-slapping and provision of cases of beer for the boys on the dockside can substitute for a modicum of competence.

If Lamont wish to use Manzanillo as a mobilization or demobilization port in the future, they should seriously consider appointing a competent agent who is able to arrange shipments of scientific equipment to and from other parts of the world.



**Appendix 3**  
**Cambridge Table 1—OBS Deployments and Recoveries**



| R/V Maurice Ewing Cruise 97-07 ARAD         |             |                 |               |                   |             |                     |                    |                     |                     |                      |                      |                    |                        |
|---|-------------|-----------------|---------------|-------------------|-------------|---------------------|--------------------|---------------------|---------------------|----------------------|----------------------|--------------------|------------------------|
| East Pacific Rise OSC 3-D Experiment        |             |                 |               |                   |             |                     |                    |                     |                     |                      |                      |                    |                        |
| Cambridge MiniDOBS Ocean Bottom Instruments |             |                 |               |                   |             |                     | DEPLOYMENT         |                     |                     |                      | RECOVERY             |                    |                        |
| Instru-<br>ment No.                         | Site<br>No. | Release<br>Type | Release<br>No | Second<br>Release | Rlg<br>Type | Hydr or<br>Geophone | Date/Time<br>(GMT) | Latitude<br>Degrees | Latitude<br>Minutes | Longitude<br>Degrees | Longitude<br>Minutes | Date/Time<br>(GMT) | COMMENTS               |
| 26  | O 28        | Internal        | 47            | No                | Short       | Int Geo             | 258 03:30          | 9                   | 1.47                | 104                  | 12.03                | 294 15:32          |                        |
| 27  | O 29        | Internal        | 49            | No                | Short       | Ext Geo             | 258 19:56          | 9                   | 1.491               | 104                  | 16.108               | 294 17:20          | No Flashing Light      |
| 28  | O 03        | Internal        | 48            | No                | Short       | Hydr                | 258 18:14          | 9                   | 8.951               | 104                  | 14.041               | 295 11:10          |                        |
| 29  | O 30        | Internal        | 45            | No                | Short       | Ext Geo             | 258 04:55          | 9                   | 4.469               | 104                  | 12.001               | 294 14:05          |                        |
| 30  | O 05        | Internal        | 44            | No                | Short       | Ext Geo             | 258 07:03          | 9                   | 8.945               | 104                  | 7.105                | 293 19:12          |                        |
| 31  | O 27        | Internal        | 46            | No                | Short       | Ext Geo             | 257 11:17          | 8                   | 57.032              | 104                  | 7.123                | 293 23:35          | Battery sphere flooded |
| 32  | O 21        | Internal        | New           | No                | Short       | Hydr                | 258 02:35          | 9                   | 0.048               | 104                  | 11.952               |                    | Lost                   |
| 33  | O 16        | RT 661          | 101           | MA 003            | Long        | Hydr                | 257 13:22          | 9                   | 3.012               | 104                  | 9.535                | 294 19:35          |                        |
| 34  | O 09        | RT 661          | 131           | MA 004            | Long        | Hydr                | 258 06:02          | 9                   | 5.94                | 104                  | 12.077               | 294 03:20          |                        |
| 35  | O 19        | RT 661          | 132           | No                | Long        | Hydr                | 258 20:36          | 9                   | 0.021               | 104                  | 16.095               | 294 18:32          |                        |
| 36  | O 23        | RT 661          | 191           | No                | Long        | Hydr                | 258 21:27          | 8                   | 57.02               | 104                  | 20.988               | 296 00:53          |                        |
| 37  | O 25        | RT 661          | 193           | No                | Long        | Hydr                | 258 01:47          | 8                   | 57.032              | 104                  | 14.042               | 295 22:59          |                        |
| 38  | O 14        | RT 661          | 93            | No                | Long        | Hydr                | 258 04:21          | 9                   | 3.004               | 104                  | 14.041               | 294 12:15          |                        |
| 39  | O 12        | RT 661          | 245           | No                | Long        | Hydr                | 258 22:24          | 9                   | 2.991               | 104                  | 18.541               | 295 05:40          |                        |
| 40  | O 01        | RT 661          | 291           | No                | Long        | Hydr                | 258 23:21          | 9                   | 8.919               | 104                  | 20.976               | 295 09:35          |                        |
| 41  | O 07        | RT 661          | 338           | No                | Long        | Hydr                | 258 18:55          | 9                   | 5.964               | 104                  | 16.147               | 295 07:35          |                        |



## **Appendix 4**

### **Cambridge Table 2— Summary of OBS data recovery**



|                             |                 |                             | <b>R/V Maurice Ewing Cruise 97-07 ARAD</b>         |                             |                              |                              |                                 |   |                           |
|-----------------------------|-----------------|-----------------------------|--|-----------------------------|------------------------------|------------------------------|---------------------------------|---|---------------------------|
|                             |                 |                             | <b>East Pacific Rise OSC 3-D Experiment</b>        |                             |                              |                              |                                 |   |                           |
|                             |                 |                             | <b>Cambridge MiniDOBS Ocean Bottom Instruments</b> |                             |                              |                              |                                 |   |                           |
| <b>Instru-<br/>ment No.</b> | <b>Site No.</b> | <b>Hydr or<br/>Geophone</b> | <b>Latitude<br/>Degrees</b>                        | <b>Latitude<br/>Minutes</b> | <b>Longitude<br/>Degrees</b> | <b>Longitude<br/>Minutes</b> | <b>Recovered<br/>with data?</b> | <b>Volume of Data<br/>Recorded (Gb)</b> | <b>Comments</b>           |
| 26                          | O 28            | Int Geo                     | 9  | 01.470                      | 104                          | 12.030                       | No                              | 0                                       | No data                   |
| 27                          | O 29            | Ext Geo                     | 9  | 01.491                      | 104                          | 16.108                       | Yes                             | 0.5                                     | Good data up to 0819Z/271 |
| 28                          | O 03            | Hydr                        | 9  | 08.951                      | 104                          | 14.041                       | Yes                             | 1.3                                     | OK                        |
| 29                          | O 30            | Ext Geo                     | 9  | 04.469                      | 104                          | 12.001                       | Yes                             | 2.1                                     | OK                        |
| 30                          | O 05            | Ext Geo                     | 9  | 08.945                      | 104                          | 07.105                       | Yes                             | 2.1                                     | OK                        |
| 31                          | O 27            | Ext Geo                     | 8  | 57.032                      | 104                          | 07.123                       | No                              | 0                                       | Battery sphere flooded    |
| 32                          | O 21            | Hydr                        | 9  | 00.048                      | 104                          | 11.952                       | No                              | 0                                       | LOST                      |
| 33                          | O 16            | Hydr                        | 9  | 03.012                      | 104                          | 09.535                       | No                              | 0                                       | No data                   |
| 34                          | O 09            | Hydr                        | 9  | 05.940                      | 104                          | 12.077                       | No                              | 0                                       | No data                   |
| 35                          | O 19            | Hydr                        | 9  | 00.021                      | 104                          | 16.095                       | Yes                             | 1.3                                     | OK                        |
| 36                          | O 23            | Hydr                        | 8  | 57.020                      | 104                          | 20.988                       | Yes                             | 1.3                                     | OK                        |
| 37                          | O 25            | Hydr                        | 8  | 57.032                      | 104                          | 14.042                       | Yes                             | 1.3                                     | OK                        |
| 38                          | O 14            | Hydr                        | 9  | 03.004                      | 104                          | 14.041                       | Yes                             | 1.3                                     | OK                        |
| 39                          | O 12            | Hydr                        | 9  | 02.991                      | 104                          | 18.541                       | Yes                             | 1.3                                     | OK                        |
| 40                          | O 01            | Hydr                        | 9  | 08.919                      | 104                          | 20.976                       | Yes                             | 1.3                                     | OK                        |
| 41                          | O 07            | Hydr                        | 9  | 05.964                      | 104                          | 16.147                       | Yes                             | 1.3                                     | OK                        |



**Appendix 5**  
**Lcheapo Table 1—OBH Launch Information**



| IGPP<br>LAUNCH<br>SEQ. | Unit Name              | Unit<br># | PCMCIA<br>Size | Release<br># | Time<br>Base | Int. Freq. | D | E  | R  | Hold<br>burn | Radio<br>Freq.<br>Mhz | Type | ARAD<br>site # | Latitude    | Longitude     |
|------------------------|------------------------|-----------|----------------|--------------|--------------|------------|---|----|----|--------------|-----------------------|------|----------------|-------------|---------------|
| 1                      | DESTROYER              | 29        | 2 MB           | 103          | 2            | 10.5 Khz   | 0 | 3  | 13 | no           | 154.585               | MT   | 22             | 8° 59.997 N | 104° 09.549 W |
| 2                      | GAMERA                 | 51        | 2 MB           | 733          | 8            | 13.5 Khz   | 1 | 5  | 13 | yes          | 160.785               | LC   | 17             | 9° 03.005 N | 104° 07.078 W |
| 3                      | BAMBI                  | 25        | 4 MB           | 713          | 2            | 13.0 Khz   | 2 | 3  | 14 | yes          | 159.480               | MT   | 10             | 9° 05.960 N | 104° 09.545 W |
| 4                      | GODZILLA<br>(tethered) | 47        | 2 MB           | 203          | 2            | 14.0 Khz   | 1 | 10 | 13 | yes          | 160.785               | MT   | 15             | 9° 02.717 N | 104° 12.084 W |
| 5                      | MONSTER ZERO           | 23        | 2 MB           | 201          | 2            | 11.0 Khz   | 2 | 5  | 11 | yes          | 160.725               | MT   | 20             | 8° 59.980 N | 104° 14.072 W |
| 6                      | GORGO                  | 24        | 4 MB           | 714          | 2            | 13.5 Khz   | 4 | 9  | 11 | yes          | 159.480               | MT   | 24             | 8° 57.032 N | 104° 16.091 W |
| 7                      | GIGAN                  | 49        | 2 MB           | 101          | 2            | 11.0 Khz   | 4 | 9  | 14 | no           | 160.725               | MT   | 26             | 8° 57.006 N | 104° 12.024 W |
| 8                      | SEA MONSTER            | 36        | 2 MB           | 202          | 2            | 10.0 Khz   | 2 | 9  | 7  | yes          | 160.725               | MT   | 4              | 9° 08.949 N | 104° 12.010 W |
| 9                      | MEGALON                | 48        | 2 MB           | 102          | 2            | 11.0 Khz   | 1 | 10 | 7  | no           | 154.585               | MT   | 8              | 9° 06.006 N | 104° 14.035 W |
| 10                     | SMOG MONSTER           | 35        | 2 MB           | 731          | 8            | 11.0 Khz   | 4 | 9  | 11 | yes          | 160.785               | LC   | 13             | 9° 03.000 N | 104° 16.081 W |
| 11                     | GHIDORAH               | 39        | 2 MB           | 732          | 8            | 13.0 Khz   | 8 | 3  | 7  | yes          | 160.785               | LC   | 18             | 8° 59.987 N | 104° 18.574 W |
| 12                     | GODZUKI                | 37        | 4 MB           | 711          | 2            | 10.5 Khz   | 1 | 3  | 7  | yes          | 159.480               | MT   | 11             | 9° 02.996 N | 104° 12.008 W |
| 13                     | KING KONG              | 2         | 4 MB           | 9            | 8            | 14.5 Khz   | 4 | 9  | 7  | yes          | 159.300               | LC   | 6              | 9° 05.981 N | 104° 18.539 W |
| 14                     | MOTHRA                 | 50        | 2 MB           | 712          | 2            | 9.5 Khz    | 4 | 5  | 13 | yes          | 160.785               | LC   | 2              | 9° 08.966 N | 104° 16.075 W |



## **Appendix 6**

### **Lcheapo Table 2—Summary of OBH Data Recovery**



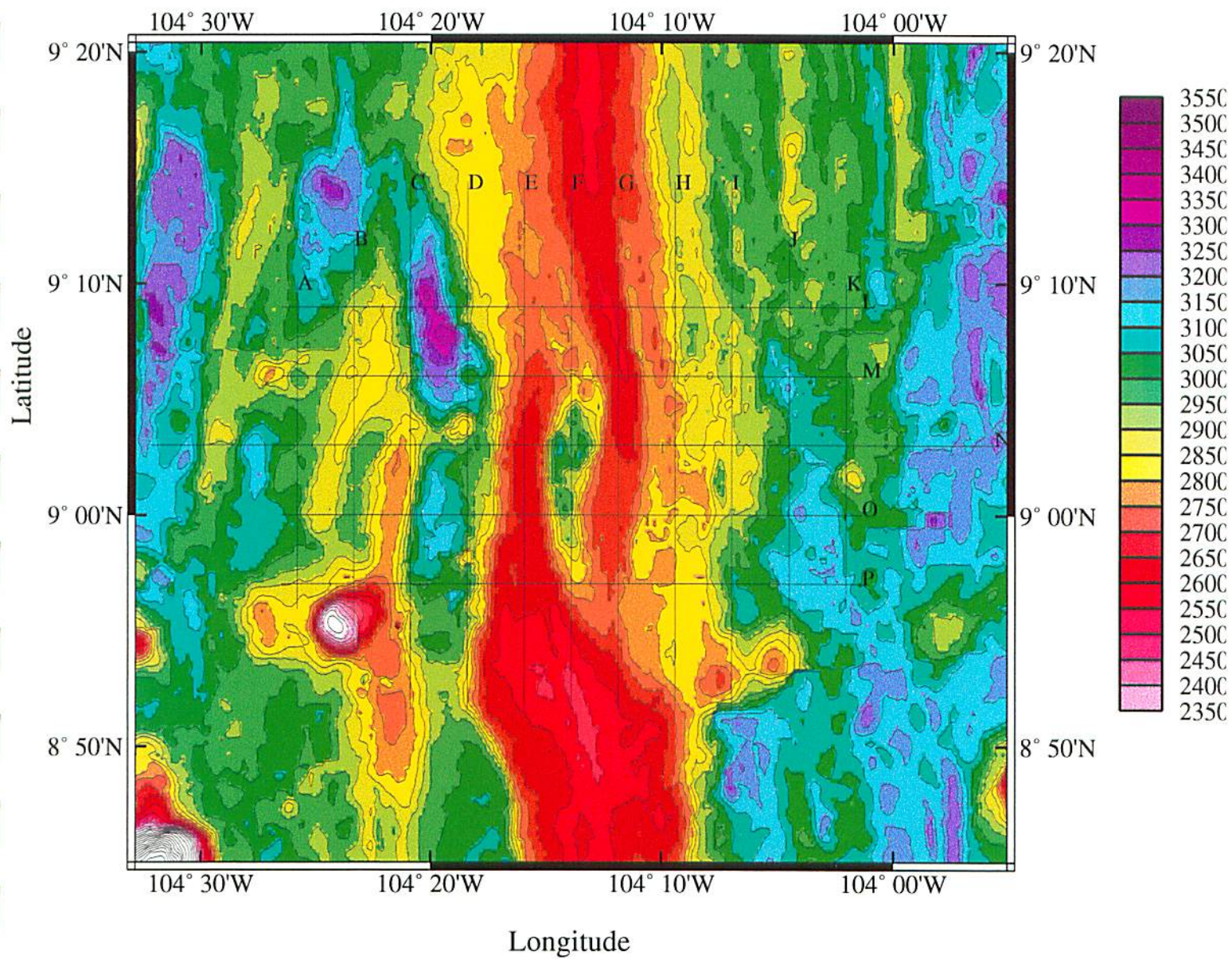
| Instrument Name     | Latitude (N)<br>Initial Est. | Latitude (N)<br>Final | Longitude (W)<br>Initial Est. | Longitude (W)<br>Final | Depth<br>(m) | Data<br>(Gb) | Drift Endpoint (Beg)<br>(Julian Date) | Drift Endpoint (End)<br>(Julian Date) | Total Drift<br>(ms) | Deploy Length<br>(days) | Drift<br>(ms/day) |
|---------------------|------------------------------|-----------------------|-------------------------------|------------------------|--------------|--------------|---------------------------------------|---------------------------------------|---------------------|-------------------------|-------------------|
| Destroyer           | 8° 59.997                    | 8°59.981              | 104° 09.549                   | 104°09.508             | 2821         | 1.617        | 257 14:23:00.99998                    | 295 03:56:00.94607                    | -53.9               | 37.5                    | -1.44             |
| Gamera              | 9° 03.005                    | 9°02.864              | 104° 07.078                   | 104°07.030             | 2923         | 1.602        | 257 15:43:00.00000                    | 293 22:01:00.88043                    | -119.6              | 36.3                    | -3.29             |
| Bambi               | 9° 05.960                    | 9°05.902              | 104° 09.545                   | 104°09.580             | 2780         | 1.613        | 257 17:04:00.99998                    | 294 05:48:00.9303                     | -69.7               | 36.5                    | -1.91             |
| Godzilla (tethered) | 9° 02.717                    | 9°02.744              | 104° 12.084                   | 104°12.097             | 1644         | 1.604        | 257 18:19:00.99997                    | 294 10:47:00.0188                     | 18.8                | 36.7                    | 0.51              |
| Monster Zero        | 8° 59.980                    | 8°59.999              | 104° 14.072                   | 104°14.199             | 2903         | 1.606        | 257 20:12:00.99998                    | 294 21:23:00.9747                     | -25.3               | 37.0                    | -0.68             |
| Gorgo               | 8° 57.032                    | 8°57.043              | 104° 16.091                   | 104°16.185             | 2627         | 1.600        | 257 20:55:00.99997                    | 295 17:13:00.0430                     | 43.0                | 37.8                    | 1.14              |
| Gigan               | 8° 57.006                    | 8°56.997              | 104° 12.024                   | 104°12.094             | 2686         | 1.602        | 257 21:50:00.99999                    | 295 19:24:00.02315                    | 23.2                | 37.9                    | 0.61              |
| Sea Monster         | 9° 08.949                    | 9°08.894              | 104° 12.010                   | 104°12.086             | 2572         | 1.585        | 258 07:39:00.00366                    | 294 07:29:00.9622                     | -41.5               | 36.0                    | -1.15             |
| Megalon             | 9° 06.006                    | 9°05.941              | 104° 14.035                   | 104°14.164             | 2803         | 1.582        | 258 08:26:00.99999                    | 294 09:02:00.95670                    | -43.3               | 36.0                    | -1.20             |
| Smog Monster        | 9° 03.000                    | 9°02.971              | 104° 16.081                   | 104°16.220             | 2589         | 1.578        | 258 09:24:00.99997                    | 294 21:09:00.0521                     | 52.1                | 36.5                    | 1.43              |
| Ghidrah             | 8° 59.987                    | 8°59.978              | 104° 18.574                   | 104°18.671             | 3007         | 1.580        | 258 10:04:00.99997                    | 295 00:31:00.03017                    | 30.2                | 36.6                    | 0.83              |
| Godzuki             | 9° 02.996                    | 9°02.978              | 104° 21.008                   | 104°21.089             | 2823         | 1.574        | 258 11:02:40.99997                    | 295 01:01:00.79300                    | -207.0              | 36.6                    | -5.65             |
| King Kong           | 9° 05.981                    | 9°05.976              | 104° 18.539                   | 104°18.596             | 2986         | 1.576        | 258 12:13:00.99998                    | 295 14:50:00.99070                    | -9.3                | 37.1                    | -0.25             |
| Mothra              | 9° 08.966                    | 9°08.947              | 104° 16.075                   | 104°16.045             | 2754         | 1.574        | 258 13:39:00.99998                    | 295 13:38:00.9866                     | -13.4               | 37.0                    | -0.36             |
| Sir Charles Barkley | 9° 03.091                    | 9°03.091              | 104° 25.938                   | 104°25.938             | 3000         | 0.025        | 296 01:22:00.99999                    | 296 11:57:00.00016                    | 0.2                 | 0.4                     | 0.39              |



**Appendix 7**  
**ARAD OBH Line Convention**



# ARAD OBH Line Convention





## ARAD OBH LINE INFO

| Shot#             | TIME                | Latitude   | Longitude    |
|-------------------|---------------------|------------|--------------|
| <u>shotsOBH A</u> |                     |            |              |
| 008761            | 97 263 16 19 40.577 | 09 10.5665 | -104 25.8195 |
| 008879            | 97 263 19 56 00.219 | 08 53.9697 | -104 25.8282 |
| <u>shotsOBH B</u> |                     |            |              |
| 008900            | 97 263 20 34 30.616 | 08 53.7091 | -104 23.4540 |
| 009041            | 97 264 00 53 00.505 | 09 12.0733 | -104 23.4365 |
| <u>shotsOBH C</u> |                     |            |              |
| 009084            | 97 264 02 59 30.704 | 09 15.5396 | -104 21.0277 |
| 009220            | 97 264 07 08 50.296 | 08 56.8320 | -104 20.9661 |
| <u>shotsOBH F</u> |                     |            |              |
| 001562            | 97 261 21 25 50.308 | 09 14.9337 | -104 13.9548 |
| 001736            | 97 262 02 44 51.009 | 08 51.3968 | -104 14.0948 |
| <u>shotsOBH I</u> |                     |            |              |
| 001334            | 97 261 14 18 20.535 | 08 51.8237 | -104 07.0869 |
| 001506            | 97 261 19 43 10.587 | 09 14.6847 | -104 07.1130 |
| <u>shotsOBH J</u> |                     |            |              |
| 001162            | 97 261 09 03 01.112 | 09 11.8103 | -104 04.6003 |
| 001292            | 97 261 13 01 20.919 | 08 53.9583 | -104 04.6395 |
| <u>shotsOBH K</u> |                     |            |              |
| 001008            | 97 261 04 20 41.061 | 08 55.6970 | -104 02.1525 |
| 001124            | 97 261 07 53 20.313 | 09 09.8633 | -104 02.1709 |
| <u>shotsOBH L</u> |                     |            |              |
| 000016            | 97 259 16 04 01.071 | 09 08.9797 | -104 01.6634 |
| 000170            | 97 259 21 37 00.556 | 09 08.9800 | -104 26.6337 |
| <u>shotsOBH M</u> |                     |            |              |
| 008505            | 97 263 08 30 21.006 | 09 05.9828 | -104 00.6909 |
| 008707            | 97 263 14 40 40.355 | 09 06.0141 | -104 26.8330 |
| <u>shotsOBH N</u> |                     |            |              |
| 000445            | 97 260 11 08 30.579 | 09 03.0721 | -103 53.4102 |
| 000724            | 97 260 19 40 00.655 | 09 02.9741 | -104 32.4923 |
| <u>shotsOBH P</u> |                     |            |              |
| 000789            | 97 260 21 39 10.353 | 08 56.9662 | -104 27.3626 |
| 000977            | 97 261 03 23 50.610 | 08 57.0163 | -104 01.3061 |



## Appendix 8

### Lcheapo Relocation Results

#### **OBS gamera**

Change in position [ 0.096 -0.251]  
Original position [-104.118030 9.050000,-2.981]  
Updated position [-104.117156 9.047731,-2.902]  
Interpolated depth 2923.640  
Original residuals RMS: 0.098 Mean: 0.040  
Inverted residuals RMS: 0.007 Mean: 0.000

-----

#### **OBS mothra**

Change in position [ 0.055 -0.035]  
Original position [-104.267917 9.149433,-2.756]  
Updated position [-104.267421 9.149117,-2.743]  
Interpolated depth 2754.277  
Original residuals RMS: 0.026 Mean:-0.009  
Inverted residuals RMS: 0.006 Mean: 0.000

-----

#### **OBS bambi**

Change in position [-0.064 -0.107]  
Original position [-104.159083 9.099333,-2.798]  
Updated position [-104.159664 9.098369,-2.758]  
Interpolated depth 2780.575  
Original residuals RMS: 0.025 Mean:-0.010  
Inverted residuals RMS: 0.003 Mean: 0.000

-----

#### **OBS godzuki**

Change in position [-0.147 -0.032]  
Original position [-104.350133 9.049933,-2.836]  
Updated position [-104.351475 9.049640,-2.807]  
Interpolated depth 2823.476  
Original residuals RMS: 0.037 Mean: 0.014  
Inverted residuals RMS: 0.004 Mean:-0.001

-----

#### **OBS king\_kong**

Change in position [-0.104 -0.008]  
Original position [-104.308983 9.099683,-3.002]  
Updated position [-104.309929 9.099607,-2.980]  
Interpolated depth 2986.300  
Original residuals RMS: 0.013 Mean:-0.001  
Inverted residuals RMS: 0.002 Mean: 0.000

-----

#### **OBS gigan**

Change in position [-0.129 -0.016]  
Original position [-104.200400 8.950100,-2.656]  
Updated position [-104.201569 8.949956,-2.667]  
Interpolated depth 2686.736  
Original residuals RMS: 0.055 Mean:-0.019  
Inverted residuals RMS: 0.004 Mean: 0.000



**OBS smog\_monster**

Change in position [-0.254 -0.054]  
Original position [-104.268017 9.050000,-2.597]  
Updated position [-104.270330 9.049510,-2.587]  
Interpolated depth 2589.636  
Original residuals RMS: 0.037 Mean: 0.006  
Inverted residuals RMS: 0.002 Mean: 0.000

-----

**OBS ghidorah**

Change in position [-0.177 -0.017]  
Original position [-104.309567 8.999783,-3.012]  
Updated position [-104.311181 8.999626,-3.025]  
Interpolated depth 3007.707  
Original residuals RMS: 0.022 Mean: 0.004  
Inverted residuals RMS: 0.003 Mean: 0.000

-----

**OBS megalon**

Change in position [-0.238 -0.119]  
Original position [-104.233900 9.100100,-2.855]  
Updated position [-104.236065 9.099027,-2.790]  
Interpolated depth 2803.231  
Original residuals RMS: 0.074 Mean: 0.003  
Inverted residuals RMS: 0.002 Mean: 0.000

-----

**OBS sea\_monster**

Change in position [-0.139 -0.101]  
Original position [-104.200167 9.149150,-2.600]  
Updated position [-104.201428 9.148236,-2.579]  
Interpolated depth 2572.460  
Original residuals RMS: 0.023 Mean: 0.002  
Inverted residuals RMS: 0.002 Mean: 0.000

-----

**OBS gorgo**

Change in position [-0.173 0.020]  
Original position [-104.268183 8.950533,-2.644]  
Updated position [-104.269757 8.950710,-2.626]  
Interpolated depth 2627.116  
Original residuals RMS: 0.023 Mean: 0.000  
Inverted residuals RMS: 0.002 Mean: 0.000

-----

**OBS monster\_zero**

Change in position [-0.233 0.035]  
Original position [-104.234533 8.999667,-2.871]  
Updated position [-104.236657 8.999979,-2.880]  
Interpolated depth 2903.897  
Original residuals RMS: 0.029 Mean: 0.007  
Inverted residuals RMS: 0.002 Mean: 0.000



**OBS destroyer**

Change in position [ 0.074 -0.029]

Original position [-104.159150 8.999950,-2.852]

Updated position [-104.158474 8.999691,-2.812]

Interpolated depth 2821.436

Original residuals RMS: 0.011 Mean:-0.004

Inverted residuals RMS: 0.002 Mean: 0.000

-----

**OBS godzilla**

Change in position [-0.023 0.051, 0.098]

Original position [-104.201400 9.045280,-1.650]

Updated position [-104.201609 9.045738,-1.552]

Interpolated depth 2644.117

Original residuals RMS: 0.041 Mean:-0.030

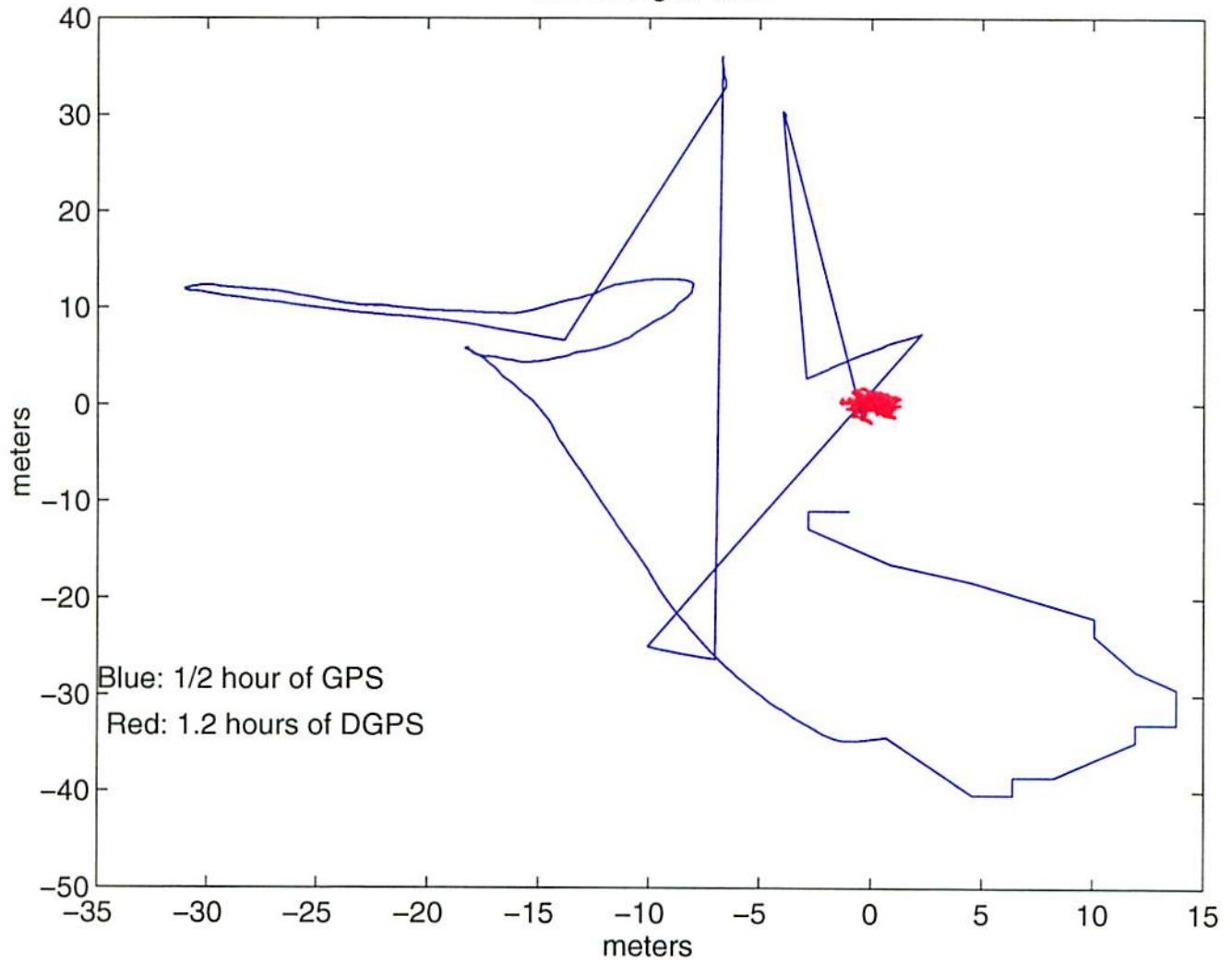
Inverted residuals RMS: 0.018 Mean: 0.000



**Appendix 9**  
**DGPS Measurements at Dockside**

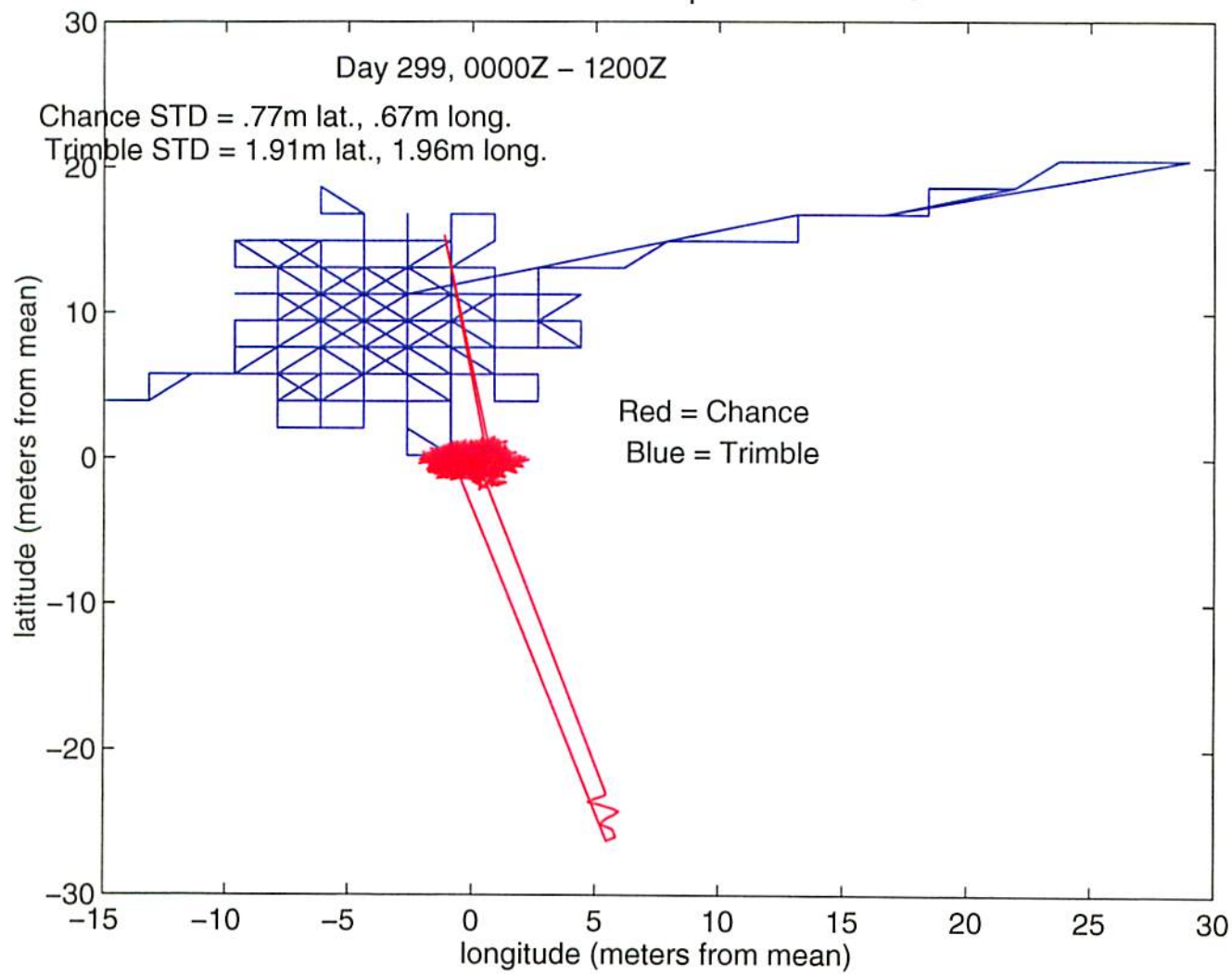


# R/V Ewing at dock





# Trimble vs Chance at pier in Manzanillo

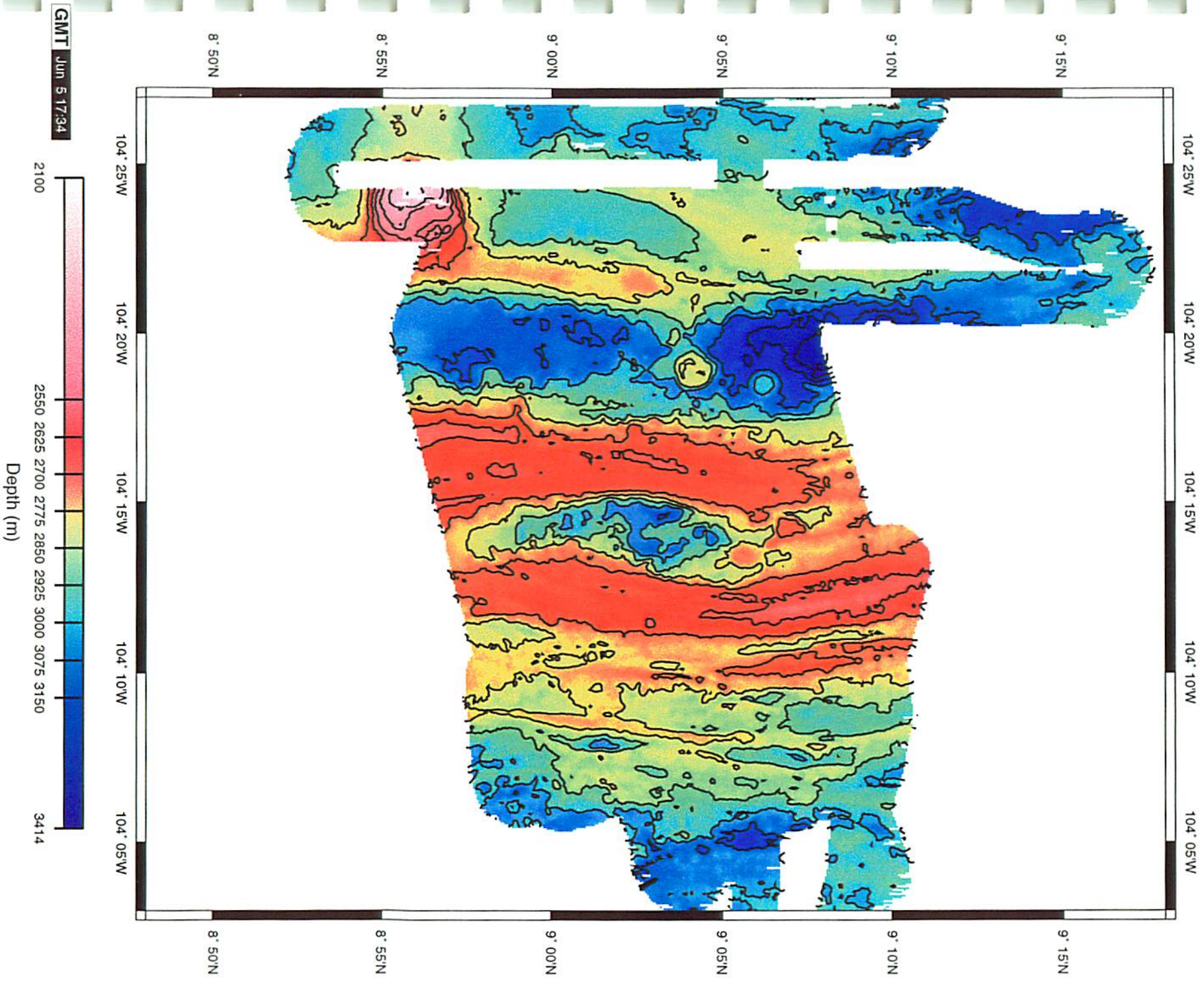




**Appendix 10**  
**Final Multibeam Bathymetry Map & Scripts**

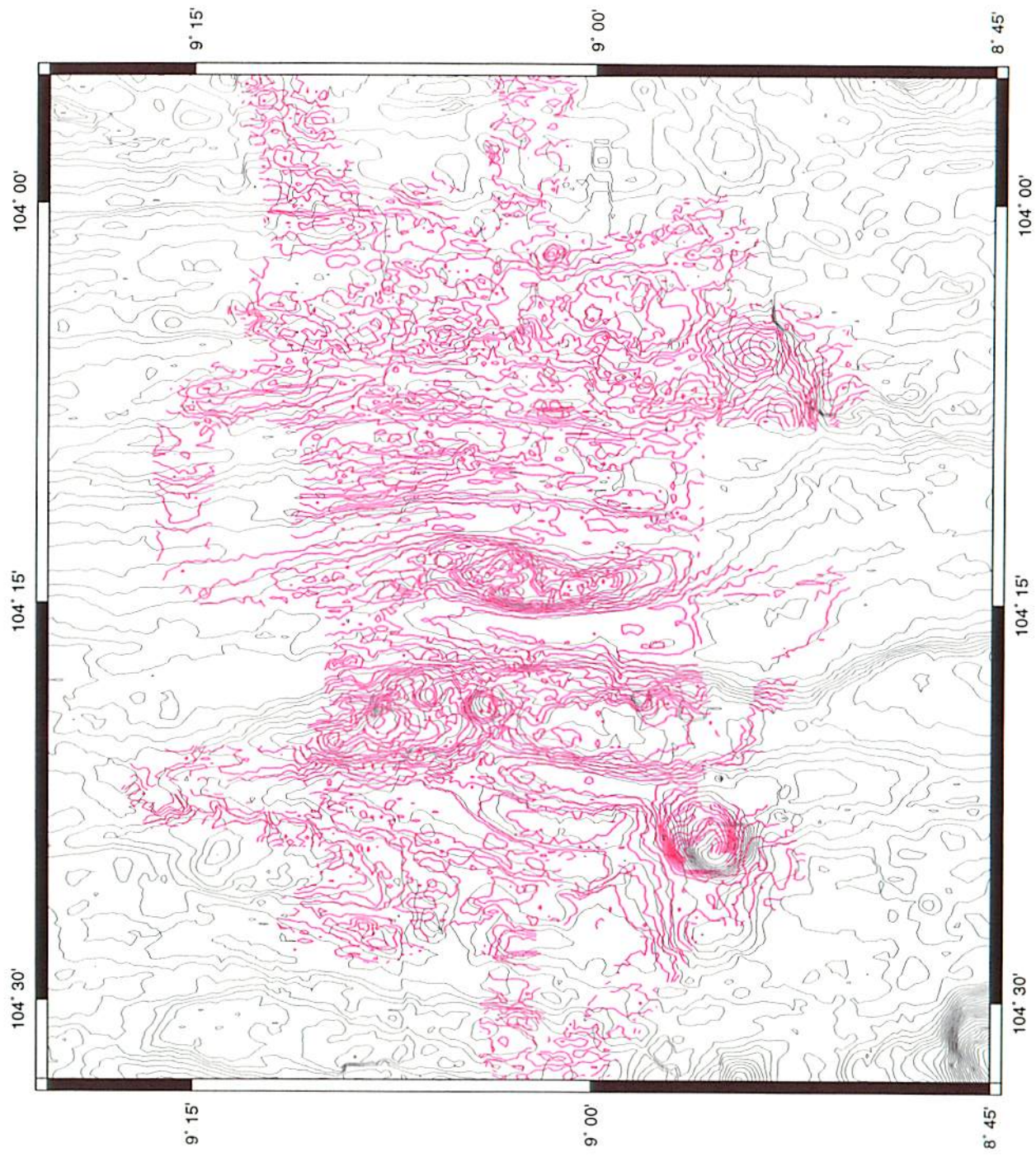


File aradall.grd - Bathymetry Grid





ARAD Bathymetry Comparison





## VELOCITY.ARAD.XBT

|              |             |
|--------------|-------------|
| 0.000000     | 1534.080000 |
| 10.000000    | 1543.473789 |
| 20.000000    | 1543.191099 |
| 30.000000    | 1543.027622 |
| 50.000000    | 1531.151865 |
| 75.000000    | 1511.761665 |
| 100.000000   | 1505.747705 |
| 125.000000   | 1502.204482 |
| 150.000000   | 1500.712954 |
| 200.000000   | 1499.277856 |
| 250.000000   | 1498.373145 |
| 300.000000   | 1497.593687 |
| 400.000000   | 1494.005859 |
| 500.000000   | 1490.693247 |
| 600.000000   | 1487.958989 |
| 700.000000   | 1486.188208 |
| 800.000000   | 1485.789556 |
| 900.000000   | 1484.935176 |
| 1000.000000  | 1484.817925 |
| 1100.000000  | 1484.933110 |
| 1200.000000  | 1485.392002 |
| 1300.000000  | 1485.498848 |
| 1400.000000  | 1486.507695 |
| 1500.000000  | 1486.769429 |
| 1750.000000  | 1489.157471 |
| 2000.000000  | 1491.802461 |
| 2500.000000  | 1498.499023 |
| 3000.000000  | 1506.799194 |
| 3500.000000  | 1515.508789 |
| 4000.000000  | 1524.299561 |
| 4500.000000  | 1533.165161 |
| 5000.000000  | 1542.099243 |
| 5500.000000  | 1551.095215 |
| 6000.000000  | 1560.146362 |
| 6500.000000  | 1569.246216 |
| 7000.000000  | 1578.387817 |
| 7500.000000  | 1587.564331 |
| 8000.000000  | 1596.768555 |
| 8500.000000  | 1605.993774 |
| 9000.000000  | 1615.232422 |
| 9500.000000  | 1624.477539 |
| 10000.000000 | 1633.721436 |
| 10500.000000 | 1642.956909 |
| 11000.000000 | 1652.176147 |
| 11500.000000 | 1661.371582 |
| 12000.000000 | 1670.535400 |



## runMBascii2bin.csh

```
#!/bin/csh -f
#
#####
# GET MB FILE READY FOR EDITING #
#####

# loop through all shooting days

set ids = `awk 'BEGIN{for (i=260; i<=296; i++) printf "%03d ", i; }'`

### begin foreach, FIRST 36 days
foreach i ($ids)
echo Processing JD DAY: $i

#convert ascii 2 binary files to make faster, we'll save these files
/net/osc2/MB/mbsystem/bin/mbcopy -F21/24 -I./raw-mb/hs/9707hs.d$i \
-O9707hsB.d$i -V

#using our XBT, convert to depth, each ping
/net/osc2/MB/mbsystem/bin/mbbath -F24 -I9707hsB.d$i -Wvelocity.arad.xbt \
-O9707hsBATH.d$i -V

#to reduce dataset and likely bad soundings, wack out beams <-1.5 km
/net/osc2/MB/mbsystem/bin/mbcut -F24 -A0/2/-5000./-1500. -I9707hsBATH.d$i \
-O9707hsBATHC.d$i -V
/bin/rm -f 9707hsBATH.d$i

#to reduce dataset and likely bad soundings, wack out beams >+1.5 km
/net/osc2/MB/mbsystem/bin/mbcut -F24 -A0/2/1500./5000. -I9707hsBATHC.d$i \
-O9707hsBATHC2.d$i -V
/bin/rm -f 9707hsBATHC.d$i

###
end
### end foreach i, end each day
```



### run.mbedit.csh

```
#!/bin/csh -f
#
/net/osc2/MB/mbsystem/bin/mbedit -F24 -I9707hsBATH.NOC2.d261 \
-O9707hsBATH.NOC2E.d261
```

### run.REmbmerge.csh

```
#!/bin/csh -f
#
/net/osc2/MB/mbsystem/bin/mbedit -F24 -I9707hsBATH.NOC2.d261 -
O9707hsBATH.NOC2E.d261
dmo 138%:more run.REmbmerge.csh
#!/bin/csh -f
#

### begin foreach, -1.5 to + 1.5 km MB swath)
foreach i (262 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 \
          279 280 281 282 283 284 285 286 287 288 289 290 291 292)
echo Processing JD DAY: $i

/net/osc2/MB/mbsystem/bin/mbmerge -F24 -I9707hsBATHC2E.d$i -M5 \
-N/net/breccia/harding/matlab/arad3d/nc.d/nc.$i -O9707hsBATHC2EMERGE.d$i

###
end
### end foreach i, end each day

### begin foreach, TOTAL SWATH

foreach i (259 260 261 263 293 296)
echo Processing JD DAY: $i

/net/osc2/MB/mbsystem/bin/mbmerge -F24 -I9707hsBATH.NOC2E.d$i -M5 \
-N/net/breccia/harding/matlab/arad3d/nc.d/nc.$i -O9707hsBATH.NOC2EMERGE.d$i

###
end
```



## run.mbgrid.all.csh

```
#!/bin/csh -f
```

```
#
```

```
cat > file.list.all << !
```

```
9707hsBATH.NOC2EMERGE.d259 24  
9707hsBATH.NOC2EMERGE.d260 24  
9707hsBATH.NOC2EMERGE.d261 24  
9707hsBATHC2EMERGE.d262 24  
9707hsBATH.NOC2cEMERGE.d262 24  
9707hsBATH.NOC2EMERGE.d263 24  
9707hsBATHC2EMERGE.d264 24  
9707hsBATHC2EMERGE.d265 24  
9707hsBATHC2EMERGE.d266 24  
9707hsBATHC2EMERGE.d267 24  
9707hsBATHC2EMERGE.d268 24  
9707hsBATHC2EMERGE.d269 24  
9707hsBATHC2EMERGE.d270 24  
9707hsBATHC2EMERGE.d271 24  
9707hsBATHC2EMERGE.d272 24  
9707hsBATHC2EMERGE.d273 24  
9707hsBATHC2EMERGE.d274 24  
9707hsBATHC2EMERGE.d275 24  
9707hsBATHC2EMERGE.d276 24  
9707hsBATHC2EMERGE.d277 24  
9707hsBATHC2EMERGE.d278 24  
9707hsBATHC2EMERGE.d279 24  
9707hsBATHC2EMERGE.d280 24  
9707hsBATHC2EMERGE.d281 24  
9707hsBATHC2EMERGE.d282 24  
9707hsBATHC2EMERGE.d283 24  
9707hsBATHC2EMERGE.d284 24  
9707hsBATHC2EMERGE.d285 24  
9707hsBATHC2EMERGE.d286 24  
9707hsBATHC2EMERGE.d287 24  
9707hsBATHC2EMERGE.d288 24  
9707hsBATHC2EMERGE.d289 24  
9707hsBATHC2EMERGE.d290 24  
9707hsBATHC2EMERGE.d291 24  
9707hsBATHC2EMERGE.d292 24  
9707hsBATH.NOC2EMERGE.d293 24  
!
```

```
/net/osc2/MB/mbsystem/bin/mbgrid -Ifile.list.all -A1 -G3 -F1 -E100/100/meters -N -  
Oaradall_mean \  
-R-104.75/-103.7/8.7/9.5 -V
```



## Appendix 11

### Real Time Processing Scripts

#### STACK SAIL LINE 011 (Example Line 11)

```
#!/bin/csh
set LINE = '011'
~/bin/sioseis << eof011
procs input weight geom shift despikes gather nmo
avenor smute stack diskoad prout end

input
  fno 19888 lno 20491
  rewind no
  nfskip 3
  nfiles 7
  ftr 1 ltr 124
  set 3 7 iunit 4 end
end

weight
  fno 0 lno 9999999 twp 67 0 75 0 116 0 125 0 126 0 127 0 128 0 end
end

geom
  # shot spacing of 37.5 m (dfls), 12.5 m cdp bins, 25 group spacing
  bgp 2 4 3 12 4 24 5 36 6 48 7 60 8 64 9 84 10 96 11 108 12 120
  cgp 2 4 3 12 4 24 5 36 6 48 7 60 8 64 9 84 10 96 11 108 12 120
  type 3 navfil navlog.$LINE ntrcs 128
  fs 1 ls 999999 # all shot have the same parameters (preset)
  gxp 128 -23 # RESET the closest group only.
  ggx -25
  dfls 37.5 dbrps 12.5 smear 12.5 end
end

shift
  fno 0 lno 9999999 datume 0 datumv 1500 end
end

despikes
  sets 3 3.3 5.5 6.5 alpha 2 thres 36 kill yes end
end

gather
  # Scratch file parameters, 130*40*1100*4 = 22880000 (23MB)
  maxrps 130 nwrds 1100 maxtrs 50 end
end

nmo
  vtrkwb 500 stretc 0.15
  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

avenor
sets 3 6 end
end

smute
xtp 0 1.5 1500 4 addwb yes end
end

diskoa # Write out disk file
opath istack.line$LINE end
end

prout
fno 0 lno 99999 ftr 1 ltr 1 end
end
end
eof011

chmod 444 istack.line$LINE

```



## PLT.011

```
sioseis << eof
procs diskin prout gains wbt mute filter agc plot end
diskin
  fno 521 lno 2121
  set 3 7
  ipath /scratch/dmo3/arad/istack.d/istack.line011 end
end
gains
  type 3 alpha 1.75 end
end
wbt
  solrat 1.5 sel 3.7 4.2 ses 3.1 3.3 end end
mute
  ttp 1 -.25 addwb yes end end
prout
  fno 0 lno 999999 noinc 50 ftr 0 ltr 9999 end
end
filter
  pass 5 40 ftype 0 dbdrop 24 end
end
agc
  winlen .5 center .1 end
end
plot
  dir l2r
  ! scalar 1.e-06 # for gains
  tlines 1
  scalar 3.e-07
  srpath sunfil wiggle 0
  nibs 75 trpin 75 def .05 clip .02 nsecs 4
  ann rpno taginc 25 vscale 3.3333 end
end
end
eof
xloadimage -r 270 sunfil &
suntops -w 8.0 -h 11 < sunfil > psfil
```



## Appendix 12

### MCS Daily Summary: ARAD-MCS Line Log

*line #/ start time/ end time/ duration/ 1st shot/ last shot/ # shots/ XTE(min)/ XTE(sig)/ dx/°*

#### Summary Julian Day 262 September 19th

201 262 05:08:26 262 08:00:40 02:52:14 3077 3684 608 2 9 38 3.4  
 201->168 262 08:00:40 262 08:51:05 00:50:05 3685 3845 161  
 168 262 08:51:05 262 11:41:26 02:50:21 3846 4448 603 3 21 39 0.5  
 168->135 262 11:41:26 262 12:28:30 00:46:46 4449 4607 159  
 135 262 12:28:30 262 15:13:36 02:45:07 4608 5211 604 2 11 38 -0.6  
 135->102 262 15:13:36 262 16:06:19 00:52:21 5212 5379 168  
 102 262 16:06:19 262 18:55:09 02:48:51 5380 5980 601 -3 10 39 -3.1  
 102->069 262 18:55:09 262 19:35:35 00:40:10 5981 6117 137  
 069 262 19:35:35 262 22:16:54 02:41:19 6118 6721 604 1 14 39 0.3  
 069->036 262 22:16:54 262 23:31:07 01:13:55 6722 6976 255  
 Beg 036 262 23:31:07 262 23:59:41 00:28:34 6977 7076 100

#### Summary Julian Day 263 September 20th

End 036 263 00:00:13 263 02:15:10 02:14:57 7078 7579 502  
 036->003 263 02:15:10 263 03:02:16 00:46:49 7580 7743 16  
 003 263 03:02:16 263 05:48:56 02:46:40 7744 8348 605 10 9 38 7.5

#### Summary Julian Day 264 September 21st

199 264 07:35:02 264 10:23:37 02:48:35 9297 9902 606 1 10 38 6.2  
 199->166 264 10:23:37 264 11:12:54 00:48:58 9903 10072 170  
 166 264 11:12:54 264 13:57:45 02:44:51 10073 10673 601 0 18 296 -4.2  
 166->133 264 13:57:45 264 14:49:14 00:51:13 10674 10854 181  
 133 264 14:49:14 264 17:34:58 02:45:44 10855 11458 604 1 7 38 4.1  
 133->100 264 17:34:58 264 18:29:31 00:54:16 11459 11645 187  
 100 264 18:29:31 264 21:15:07 02:45:36 11646 12249 604 0 11 38 -2.7  
 100->067 264 21:15:07 264 22:01:32 00:46:07 12250 12410 161  
 Beg 067 264 22:01:32 264 23:59:40 01:58:09 12411 12834 424

#### Summary Julian Day 265 September 22nd

End 067 265 00:00:13 265 00:49:40 00:49:27 12836 13014 179  
 067->034 265 00:49:40 265 01:34:21 00:44:22 13015 13164 150  
 034 265 01:34:21 265 04:18:05 02:43:44 13165 13766 602 -1 14 38 -2.4  
 034->001 265 04:18:05 265 05:15:47 00:57:25 13767 13967 201  
 001 265 05:16:04 265 08:02:14 02:46:10 13969 14574 606 4 6 38 1.9  
 001->032 265 08:01:41 265 08:39:03 00:37:05 14573 14698 126  
 032 265 08:39:03 265 11:26:01 02:46:58 14699 15301 603 2 9 38 -1.4  
 032->005 265 11:26:01 265 12:28:51 01:02:34 15302 15515 214  
 005 265 12:29:08 265 15:16:09 02:47:00 15517 16121 605 2 5 38 0.1  
 005->038 265 15:15:52 265 15:54:07 00:37:57 16121 16250 130  
 038 265 15:54:07 265 18:40:19 02:46:12 16251 16854 604 2 12 38 2.9  
 038->007 265 18:40:19 265 19:20:53 00:40:14 16855 16989 135  
 007 265 19:21:12 265 22:06:21 02:45:09 16991 17591 601 3 14 38 0.2  
 007->040 265 22:06:05 265 22:40:36 00:34:14 17591 17709 119  
 Beg 040 265 22:40:36 265 23:59:28 01:18:53 17710 17991 282



**Summary Julian Day 266 September 23rd**

End 040 266 00:00:01 266 01:26:46 01:26:45 17993 18313 321  
040->009 266 01:26:46 266 02:04:07 00:37:02 18314 18438 125  
009 266 02:04:07 266 04:48:28 02:44:21 18439 19040 602 1 7 38 -0.2  
009->042 266 04:48:28 266 05:27:20 00:38:35 19041 19174 134  
042 266 05:27:20 266 08:14:33 02:47:13 19175 19780 606 -3 4 38 -2.0  
042->011 266 08:14:33 266 08:47:12 00:32:21 19781 19887 107  
011 266 08:47:12 266 11:34:29 02:47:17 19888 20491 604 3 11 38 3.4  
011->044 266 11:34:29 266 12:13:50 00:39:02 20492 20626 135  
044 266 12:13:50 266 14:54:30 02:40:40 20627 21228 602 -2 5 38 -2.8  
044->013 266 14:54:30 266 15:40:42 00:45:57 21229 21393 165  
013 266 15:40:42 266 18:20:18 02:39:36 21394 22000 607 3 7 38 6.9  
013->046 266 18:20:18 266 19:05:58 00:45:20 22001 22158 158  
046 266 19:05:58 266 21:43:17 02:37:19 22159 22758 600 -3 10 38 -7.7  
046->015 266 21:43:17 266 22:19:40 00:36:06 22759 22882 124  
Beg 015 266 22:19:40 266 23:59:31 01:39:51 22883 23261 379

**Summary Julian Day 267 September 24th**

End 015 267 00:00:04 267 01:00:39 01:00:35 23263 23487 225  
015->048 267 01:00:39 267 01:57:09 00:56:12 23488 23681 194  
048 267 01:57:09 267 04:36:10 02:39:01 23682 24284 603 1 12 38 -10.0  
048->017 267 04:36:10 267 05:24:30 00:48:03 24285 24456 172  
017 267 05:24:30 267 08:14:60 02:50:29 24457 25062 606 2 7 38 4.7  
017->050 267 08:14:60 267 09:06:54 00:51:38 25063 25239 177  
050 267 09:06:54 267 11:48:09 02:41:15 25240 25845 606 -2 8 38 -3.7  
050->019 267 11:48:09 267 12:22:50 00:34:26 25846 25957 112  
019 267 12:22:50 267 15:12:17 02:49:27 25958 26562 605 0 8 38 1.9  
019->052 267 15:12:17 267 15:48:47 00:36:12 26563 26686 124  
052 267 15:48:47 267 18:27:26 02:38:39 26687 27290 604 -1 11 38 1.6  
052->021 267 18:27:26 267 19:04:59 00:37:15 27291 27416 126  
021 267 19:04:59 267 21:49:22 02:44:23 27417 28018 602 2 5 38 1.5  
021->054 267 21:49:22 267 22:38:26 00:48:44 28019 28181 163  
Beg 054 267 22:38:26 267 23:59:37 01:21:11 28182 28478 297

**Summary JDay 268 September 25th**

End 054 268 00:00:09 268 01:19:18 01:19:09 28480 28782 303  
054->023 268 01:19:18 268 01:54:08 00:34:33 28783 28897 115  
023 268 01:54:08 268 04:34:10 02:40:02 28898 29501 604 6 14 38 2.3  
023->056 268 04:34:10 268 05:23:24 00:48:56 29502 29677 176  
056 268 05:23:24 268 08:01:21 02:37:58 29678 30280 603 -2 10 38 -0.9  
056->025 268 08:01:21 268 08:36:25 00:34:48 30281 30400 120  
025 268 08:36:25 268 11:13:46 02:37:21 30401 31005 605 4 11 38 3.0  
025->058 268 11:13:46 268 11:54:08 00:40:04 31006 31141 136  
058 268 11:54:08 268 14:32:28 02:38:20 31142 31744 603 -4 14 38 -7.8  
058->027 268 14:32:28 268 15:25:18 00:52:34 31745 31925 181  
027 268 15:25:18 268 18:07:29 02:42:10 31926 32531 606 3 24 38 10.1  
027->062 268 18:07:29 268 19:01:26 00:53:38 32532 32722 191  
062 268 19:01:26 268 21:39:04 02:37:38 32723 33324 602 -4 13 38 -8.2  
062->029 268 21:39:04 268 22:17:38 00:38:16 33325 33456 132  
Beg 029 268 22:17:38 268 23:59:40 01:42:03 33457 33811 355



**Summary Julian Day 269 September 26th**

End 029 269 00:00:14 269 01:10:37 01:10:23 33813 34061 249  
029->060 269 01:10:37 269 01:43:38 00:32:43 34062 34173 112  
060 269 01:43:38 269 04:24:36 02:40:58 34174 34776 603 -7 20 38 -7.9  
060->031 269 04:24:36 269 05:24:50 00:59:58 34777 34986 210  
031 269 05:24:50 269 08:14:07 02:49:16 34987 35593 607 1 7 38 6.3  
031->064 269 08:14:07 269 09:02:48 00:48:26 35594 35761 168  
064 269 09:02:48 269 11:40:43 02:37:55 35762 36366 605 -5 14 38 -5.1  
064->033 269 11:40:43 269 12:19:57 00:38:59 36367 36492 126  
033 269 12:19:57 269 15:16:43 02:56:46 36493 37097 605 2 17 38 5.3  
033->066 269 15:16:43 269 15:50:39 00:33:41 37098 37214 117  
066 269 15:50:39 269 18:28:38 02:37:59 37215 37819 605 1 23 38 -2.3  
066->035 269 18:28:38 269 19:07:50 00:38:53 37820 37954 135  
035 269 19:07:50 269 22:00:35 02:52:45 37955 38558 604 2 6 38 1.4  
035->002 269 22:00:35 269 22:33:50 00:32:59 38559 38674 116  
Beg 002 269 22:33:50 269 23:59:45 01:25:55 38675 39013 339

**Summary Julian Day 270 September 27th**

End 002 270 00:00:15 270 01:07:13 01:06:58 39015 39278 264  
002->037 270 01:07:13 270 01:51:07 00:43:36 39279 39435 157  
037 270 01:51:07 270 04:49:53 02:58:46 39436 40040 605 0 8 38 2.4  
037->004 270 04:49:53 270 05:23:17 00:33:08 40041 40155 115  
004 270 05:23:17 270 07:58:43 02:35:26 40156 40759 604 -4 12 38 -1.0  
004->039 270 07:58:43 270 08:39:56 00:40:55 40760 40905 146  
039 270 08:39:56 270 11:28:21 02:48:24 40906 41508 603 -8 6 38 -2.5  
039->006 270 11:28:21 270 12:09:05 00:40:27 41509 41648 140  
006 270 12:09:38 270 14:48:04 02:38:25 41651 42253 603 0 10 38 0.3  
006->041 270 14:47:48 270 15:28:11 00:40:05 42253 42396 144  
041 270 15:28:11 270 18:20:14 02:52:02 42397 42998 602 -1 7 38 -0.8  
041->008 270 18:20:14 270 18:59:19 00:38:48 42999 43136 138  
008 270 18:59:53 270 21:37:24 02:37:31 43139 43741 603 2 6 38 2.0  
008->043 270 21:37:09 270 22:14:51 00:37:25 43741 43877 137  
Beg 043 270 22:14:51 270 23:59:39 01:44:47 43878 44274 397

**Summary Julian Day 271 September 28th**

End 043 271 00:00:08 271 00:52:38 00:52:30 44276 44481 206  
043->010 271 00:52:38 271 01:33:19 00:40:22 44482 44619 138  
010 271 01:33:19 271 04:13:36 02:40:17 44620 45219 600 -2 5 38 -0.8  
010->045 271 04:13:36 271 04:50:09 00:36:17 45220 45351 132  
045 271 04:50:09 271 07:29:02 02:38:53 45352 45956 605 4 10 38 3.3  
045->012 271 07:29:02 271 08:06:51 00:37:30 45957 46087 131  
012 271 08:06:51 271 10:47:25 02:40:34 46088 46689 602 -2 5 38 -4.3  
012->047 271 10:47:25 271 11:25:51 00:38:09 46690 46826 137  
047 271 11:25:51 271 14:06:25 02:40:34 46827 47429 603 5 9 38 2.9  
047->014 271 14:06:25 271 14:49:41 00:42:58 47430 47577 148  
014 271 14:49:41 271 17:31:21 02:41:39 47578 48181 604 -3 15 38 -6.9  
014->049 271 17:31:21 271 18:08:24 00:36:46 48182 48314 133  
049 271 18:08:24 271 20:49:48 02:41:24 48315 48917 603 5 16 40 7.6  
049->016 271 20:49:48 271 21:30:17 00:40:10 48918 49051 134  
Beg 016 271 21:30:17 271 23:59:41 02:29:25 49052 49613 562



**Summary Julian Day 272 September 29th**

End 016 272 00:00:13 272 00:10:48 00:10:34 49615 49655 41  
016->051 272 00:10:48 272 00:54:25 00:43:21 49656 49814 159  
051 272 00:54:25 272 03:42:28 02:48:03 49815 50419 605 3 18 38 8.9  
End->018 272 04:17:54 272 04:21:60 00:03:48 50536 50548 13  
018 272 04:21:60 272 07:00:27 02:38:27 50549 51148 600 -1 20 39 -4.8  
018->053 272 07:00:27 272 07:42:21 00:41:37 51149 51301 153  
053 272 07:42:21 272 10:32:55 02:50:34 51302 51905 604 1 7 38 4.9  
053->020 272 10:32:55 272 11:14:07 00:40:56 51906 52047 142  
020 272 11:14:07 272 13:50:47 02:36:40 52048 52650 603 -2 5 38 -4.5  
020->055 272 13:50:47 272 14:35:55 00:44:49 52651 52814 164  
055 272 14:35:55 272 17:28:03 02:52:09 52815 53419 605 2 14 38 4.0  
055->022 272 17:28:03 272 18:04:14 00:35:54 53420 53540 121  
022 272 18:04:14 272 20:40:20 02:36:07 53541 54145 605 3 13 38 -4.1  
022->057 272 20:40:20 272 21:19:19 00:38:41 54146 54281 136  
Beg 057 272 21:19:19 272 23:59:34 02:40:15 54282 54858 577

**Summary Julian Day 273 September 30th**

End 057 273 00:00:07 273 00:07:07 00:07:00 54860 54885 26  
057->024 273 00:07:07 273 00:49:17 00:41:52 54886 55027 142  
024 273 00:49:17 273 03:29:08 02:39:51 55028 55631 604 -1 7 38 -4.5  
024->059 273 03:29:08 273 04:05:40 00:36:15 55632 55762 131  
059 273 04:05:40 273 06:53:18 02:47:38 55763 56370 608 -1 9 38 -1.6  
059->026 273 06:53:18 273 07:33:18 00:39:44 56371 56508 138  
026 273 07:33:18 273 10:12:02 02:38:43 56509 57111 603 2 14 38 3.2  
026->061 273 10:12:02 273 10:49:58 00:37:39 57112 57246 135  
061 273 10:49:58 273 13:32:17 02:42:18 57247 57849 603 1 6 38 -2.3  
061->028 273 13:32:17 273 14:10:52 00:38:18 57850 57983 134  
028 273 14:10:52 273 16:50:59 02:40:07 57984 58585 602 -1 6 38 -1.1  
028->063 273 16:50:59 273 17:27:55 00:36:39 58586 58717 132  
063 273 17:27:55 273 20:09:04 02:41:09 58718 59322 605 1 10 38 2.7  
063->030 273 20:09:04 273 20:47:57 00:38:35 59323 59455 133  
030 273 20:48:16 273 23:24:59 02:36:43 59457 60058 602 -3 7 38 -3.3  
Beg->065 273 23:24:59 273 23:59:44 00:34:30 60059 60186 128

**Summary Julian Day 274 October 1st**

End->065 274 00:00:01 274 00:02:30 00:02:12 60189 60196 8  
065 274 00:02:30 274 02:38:33 02:36:03 60197 60800 604 6 6 38 2.9  
065->088 274 02:38:33 274 03:10:27 00:31:35 60801 60907 107  
088 274 03:10:27 274 05:51:20 02:40:52 60908 61508 601 -7 7 38 -5.9  
088->071 274 05:51:20 274 06:15:02 00:23:22 61509 61584 76  
071 274 06:15:02 274 08:57:38 02:42:35 61585 62185 601 5 7 39 5.6  
071->090 274 08:57:38 274 09:22:21 00:24:23 62186 62265 80  
090 274 09:22:21 274 11:03:03 01:40:41 62266 62641 376 -1 13 39 -0.4  
090->073 274 11:03:03 274 12:44:11 01:40:50 62642 63007 366  
073 274 12:44:11 274 15:24:55 02:40:44 63008 63610 603 7 6 38 4.6  
073->092 274 15:24:55 274 16:04:01 00:38:49 63611 63738 128  
092 274 16:04:01 274 18:45:25 02:41:25 63739 64343 605 -5 7 38 -5.3  
092->075 274 18:45:25 274 19:15:57 00:30:12 64344 64440 97  
075 274 19:15:57 274 21:58:44 02:42:47 64441 65045 605 2 6 38 0.1  
075->094 274 21:58:44 274 22:33:56 00:34:53 65046 65156 111  
Beg 094 274 22:33:56 274 23:59:35 01:25:39 65157 65477 321



**Summary Julian Day 275 October 2nd**

End 094 275 00:00:06 275 01:13:55 01:13:49 65479 65759 281  
094->077 275 01:13:55 275 01:44:08 00:29:55 65760 65859 100  
077 275 01:44:08 275 04:24:41 02:40:34 65860 66464 605 6 6 38 3.9  
077->096 275 04:24:41 275 04:59:48 00:34:49 66465 66582 118  
096 275 04:59:48 275 07:37:46 02:37:59 66583 67186 604 -5 5 38 -4.7  
096->079 275 07:37:46 275 08:07:51 00:29:47 67187 67286 100  
079 275 08:07:51 275 10:49:26 02:41:35 67287 67891 605 3 6 38 2.2  
079->098 275 10:49:26 275 11:20:20 00:30:35 67892 67993 102  
098 275 11:20:20 275 13:59:09 02:38:50 67994 68598 605 -2 5 38 0.0  
098->081 275 13:59:09 275 14:31:13 00:31:46 68599 68704 106  
081 275 14:31:13 275 17:10:09 02:38:56 68705 69308 604 6 5 38 4.4  
081->104 275 17:10:09 275 17:36:13 00:25:46 69309 69395 87  
104 275 17:36:13 275 20:16:24 02:40:12 69396 69997 602 -7 7 38 -6.8  
104->083 275 20:16:24 275 20:41:37 00:24:53 69998 70080 83  
083 275 20:41:37 275 23:22:32 02:40:56 70081 70683 603 3 6 38 2.9  
Beg->106 275 23:22:32 275 23:59:57 00:37:08 70684 70818 135

**Summary Julian Day 276 October 3rd**

End->106 276 00:00:12 276 01:04:50 01:04:22 70821 71067 247  
106 276 01:04:50 276 03:42:42 02:37:52 71068 71673 606 -3 7 38 -0.1  
106->085 276 03:42:42 276 04:08:37 00:25:37 71674 71760 87  
085 276 04:08:37 276 06:55:12 02:46:35 71761 72364 604 8 7 38 7.0  
085->108 276 06:55:12 276 07:25:60 00:30:31 72365 72471 107  
108 276 07:25:60 276 10:03:38 02:37:38 72472 73076 605 -6 12 38 -6.1  
108->087 276 10:03:38 276 10:31:35 00:27:37 73077 73171 95  
087 276 10:31:35 276 13:25:05 02:53:30 73172 73774 603 2 5 38 0.0  
087->110 276 13:25:05 276 13:52:28 00:27:03 73775 73861 87  
110 276 13:52:28 276 16:30:14 02:37:46 73862 74461 600 0 17 39 0.6  
110->089 276 16:30:14 276 16:55:43 00:25:09 74462 74548 87  
089 276 16:55:43 276 19:33:53 02:38:10 74549 75151 603 4 5 38 2.5  
089->068 276 19:33:53 276 20:04:30 00:30:19 75152 75254 103  
068 276 20:04:30 276 22:41:31 02:37:01 75255 75858 604 -1 6 38 -2.3  
068->091 276 22:41:31 276 23:09:14 00:27:23 75859 75952 94  
Beg 091 276 23:09:14 276 23:59:39 00:50:25 75953 76141 189

**Summary Julian Day 277 October 4th**

End 091 277 00:00:10 277 01:49:47 01:49:37 76143 76554 412  
091->070 277 01:49:47 277 02:30:03 00:39:58 76555 76688 134  
070 277 02:30:03 277 05:09:19 02:39:17 76689 77292 604 3 8 38 2.0  
070->093 277 05:09:19 277 05:43:52 00:34:15 77293 77412 120  
093 277 05:43:52 277 08:21:51 02:37:59 77413 78017 605 3 5 38 -0.3  
093->072 277 08:21:51 277 08:49:20 00:27:10 78018 78109 92  
072 277 08:49:20 277 11:28:26 02:39:06 78110 78712 603 -1 7 38 -1.5  
072->095 277 11:28:26 277 11:54:16 00:25:32 78713 78799 87  
095 277 11:54:16 277 14:31:55 02:37:40 78800 79402 603 -1 5 38 -3.2  
095->074 277 14:31:55 277 16:53:06 02:20:55 79403 79899 497  
074 277 16:53:06 277 19:35:06 02:41:59 79900 80506 607 -5 6 38 -3.8  
074->097 277 19:35:06 277 19:57:30 00:22:07 80507 80583 77  
097 277 19:57:30 277 22:36:46 02:39:17 80584 81186 603 8 12 38 4.5  
097->076 277 22:36:46 277 23:09:19 00:32:13 81187 81294 108  
Beg 076 277 23:09:19 277 23:59:42 00:50:24 81295 81485 191



### Summary Julian Day 278 October 5th

End 076 278 00:00:14 278 01:46:37 01:46:23 81487 81896 410  
076->099 278 01:46:37 278 02:12:36 00:25:41 81897 81986 90  
099 278 02:12:36 278 04:50:29 02:37:53 81987 82587 601 10 6 38 3.4  
099->078 278 04:50:29 278 05:15:59 00:25:11 82588 82670 83  
078 278 05:15:59 278 07:53:41 02:37:43 82671 83270 600 -8 13 39 -8.3  
078->101 278 07:53:41 278 08:23:26 00:29:27 83271 83377 107  
101 278 08:23:26 278 11:05:32 02:42:06 83378 83981 604 8 13 38 5.5  
101->080 278 11:05:32 278 11:47:34 00:41:45 83982 84121 140  
080 278 11:47:34 278 14:27:18 02:39:44 84122 84727 606 -4 10 38 -2.0  
080->103 278 14:27:18 278 14:53:15 00:25:39 84728 84816 89  
103 278 14:53:15 278 17:31:14 02:37:59 84817 85418 602 7 8 38 3.8  
103->082 278 17:31:14 278 17:55:52 00:24:19 85419 85500 82  
082 278 17:55:52 278 20:33:18 02:37:26 85501 86100 600 -7 9 39 -6.5  
082->105 278 20:33:18 278 21:17:46 00:44:12 86101 86263 163  
Abort105 278 21:17:46 278 21:48:05 00:30:18 86264 86372 109  
Return105 278 21:48:56 278 23:20:19 01:31:06 86376 86693 318  
Beg 105 278 23:20:19 278 23:59:38 00:39:19 86694 86840 147

### Summary Julian Day 279 October 6th

End 105 279 00:00:10 279 02:01:11 02:01:02 86842 87298 457  
105->084 279 02:01:11 279 02:40:19 00:38:50 87299 87429 131  
084 279 02:40:19 279 05:19:04 02:38:46 87430 88034 605 -3 6 38 -3.7  
084->107 279 05:19:04 279 05:47:56 00:28:33 88035 88134 100  
107 279 05:47:56 279 08:27:54 02:39:58 88135 88738 604 9 9 38 5.4  
107->086 279 08:27:54 279 08:51:49 00:23:36 88739 88815 77  
086 279 08:51:49 279 11:28:06 02:36:17 88816 89415 600 -4 8 39 -5.8  
086->109 279 11:28:06 279 11:54:44 00:26:19 89416 89509 94  
109 279 11:54:44 279 14:35:41 02:40:57 89510 90111 602 2 7 38 0.5  
109->132 279 14:35:41 279 15:06:24 00:30:24 90112 90215 104  
132 279 15:06:24 279 17:46:25 02:40:02 90216 90817 602 -1 6 38 -0.3  
132->111 279 17:46:25 279 18:11:23 00:24:39 90818 90902 85  
111 279 18:11:23 279 20:51:10 02:39:47 90903 91505 603 5 5 40 2.6  
111->134 279 20:51:10 279 21:17:13 00:25:44 91506 91591 86  
134 279 21:17:13 279 23:54:56 02:37:43 91592 92195 604 -4 8 38 -1.5  
Beg->113 279 23:54:56 279 23:59:53 00:04:40 92196 92212 17

### Summary Julian Day 280 October 7th

End->113 280 00:00:10 280 01:30:45 01:30:20 92215 92533 319  
113 280 01:32:17 280 04:09:58 02:37:41 92540 93140 601 2 7 38 -0.4  
113->136 280 04:09:58 280 04:41:53 00:31:35 93141 93246 106  
136 280 04:41:53 280 07:24:09 02:42:16 93247 93848 602 -2 6 38 -0.2  
136->115 280 07:24:09 280 07:50:50 00:26:22 93849 93938 90  
Begin 115 280 07:50:50 280 08:58:21 01:07:31 93939 94197 259 Aborted  
Return115 280 08:59:08 280 11:04:31 02:05:07 94201 94622 422  
115 280 11:04:31 280 13:48:41 02:44:10 94623 95227 605 3 29 38 3.7  
115->138 280 13:48:41 280 14:20:31 00:31:30 95228 95333 106  
138 280 14:20:31 280 17:14:56 02:54:25 95334 95937 604 -7 8 38 -5.1  
138->117 280 17:14:56 280 17:43:55 00:28:39 95938 96025 88  
117 280 17:43:55 280 20:25:42 02:41:47 96026 96628 603 14 17 38 9.4  
117->140 280 20:25:42 280 20:54:32 00:28:32 96629 96726 98  
140 280 20:54:32 280 23:41:30 02:46:58 96727 97329 603 -8 19 38 -8.4  
Beg->119 280 23:41:30 280 23:59:43 00:17:52 97330 97387 58



**Summary Julian Day 281 October 8th**

End->119 281 00:00:03 281 00:06:05 00:05:42 97390 97406 17  
119 281 00:06:05 281 03:08:30 03:02:25 97407 98011 605 12 15 38 8.6  
119->142 281 03:08:30 281 03:39:28 00:30:38 98012 98109 98  
142 281 03:39:28 281 06:21:39 02:42:11 98110 98710 601 -8 14 39 -4.9  
142->121 281 06:21:39 281 06:49:59 00:27:59 98711 98800 90  
121 281 06:49:59 281 09:45:14 02:55:15 98801 99402 602 6 10 38 4.5  
121->144 281 09:45:14 281 10:18:43 00:33:10 99403 99509 107  
144 281 10:18:43 281 12:59:01 02:40:18 99510 100112 603 -2 6 38 -1.4  
144->123 281 12:59:01 281 13:26:15 00:26:51 100113 100201 89  
123 281 13:26:15 281 16:17:40 02:51:24 100202 100803 602 -2 12 38 -1.2  
123->146 281 16:17:40 281 18:34:19 02:16:23 100804 101268 465  
146 281 18:34:19 281 21:22:09 02:47:50 101269 101873 605 -3 5 38 0.0  
146->125 281 21:22:09 281 21:51:22 00:28:52 101874 101966 93  
Beg 125 281 21:51:22 281 23:59:32 02:08:10 101967 102410 444

**Summary Julian Day 282 October 9th**

End 125 282 00:00:07 282 00:44:59 00:44:52 102412 102568 157  
125->148 282 00:44:59 282 01:15:59 00:30:41 102569 102668 100  
148 282 01:15:59 282 04:08:41 02:52:42 102669 103272 604 -3 7 38 0.2  
148->127 282 04:08:41 282 04:34:18 00:25:18 103273 103354 82  
127 282 04:34:18 282 07:23:38 02:49:20 103355 103959 605 6 7 38 4.7  
127->150 282 07:23:38 282 07:50:43 00:26:46 103960 104046 87  
150 282 07:50:43 282 10:43:30 02:52:47 104047 104649 603 -3 7 38 -3.4  
150->129 282 10:43:30 282 11:07:47 00:23:58 104650 104724 75  
129 282 11:07:47 282 13:55:51 02:48:03 104725 105324 600 0 12 39 -2.0  
129->152 282 13:55:51 282 14:29:35 00:33:25 105325 105436 112  
152 282 14:29:35 282 17:29:58 03:00:23 105437 106041 605 0 15 38 -0.2  
152->131 282 17:29:58 282 18:08:42 00:38:27 106042 106165 124  
131 282 18:08:42 282 20:54:40 02:45:58 106166 106768 603 2 11 38 1.2  
131->112 282 20:54:40 282 21:33:20 00:38:21 106769 106892 124  
Beg 112 282 21:33:20 282 23:59:39 02:26:19 106893 107339 447

**Summary Julian Day 283 October 10th**

End 112 283 00:00:18 283 00:53:06 00:52:48 107341 107501 161  
112->137 283 00:53:06 283 01:25:49 00:32:26 107502 107599 98  
137 283 01:25:49 283 04:01:09 02:35:21 107600 108205 606 2 22 38 3.6  
137->114 283 04:01:09 283 04:43:23 00:41:54 108206 108340 135  
114 283 04:43:23 283 07:58:03 03:14:40 108341 108947 607 -7 5 38 -6.3  
114->139 283 07:58:03 283 08:33:49 00:35:30 108948 109059 112  
139A 283 08:33:49 283 09:56:36 01:22:47 109060 109369 310 13 18 38 8.0  
Ret->139 283 09:57:56 283 11:55:02 01:56:49 109375 109765 391  
139B 283 11:55:02 283 13:53:01 01:58:00 109766 110206 441 15 17 38 8.9  
139->116 283 13:53:01 283 14:23:38 00:30:16 110207 110304 98  
116 283 14:23:38 283 17:16:35 02:52:57 110305 110904 600 -11 9 39 -10.1  
116->141 283 17:16:35 283 18:02:28 00:45:35 110905 111066 162  
141 283 18:02:28 283 21:02:07 02:59:39 111067 111673 607 13 10 38 10.7  
141->118 283 21:02:07 283 21:41:06 00:38:40 111674 111786 113  
Beg 118 283 21:41:06 283 23:59:36 02:18:30 111787 112308 522



**Summary Julian Day 284 October 11th**

End 118 284 00:00:07 284 00:19:55 00:19:48 112310 112389 80  
118->143 284 00:19:55 284 00:50:28 00:30:13 112390 112495 106  
143 284 00:50:28 284 03:59:01 03:08:32 112496 113100 605 8 11 38 5.0  
143->120 284 03:59:01 284 04:33:45 00:34:26 113101 113205 105  
120 284 04:33:45 284 07:13:36 02:39:51 113206 113808 603 -4 7 38 -4.5  
120->145 284 07:13:36 284 07:44:26 00:30:30 113809 113913 105  
145 284 07:44:26 284 11:00:07 03:15:41 113914 114517 604 2 5 38 0.9  
145->122 284 11:00:07 284 11:46:16 00:45:52 114518 114660 143  
122 284 11:46:16 284 14:26:11 02:39:56 114661 115266 606 0 6 38 1.3  
122->147 284 14:26:11 284 14:55:14 00:28:43 115267 115362 96  
147 284 14:55:14 284 17:58:43 03:03:29 115363 115965 603 -5 9 39 -4.9  
147->124 284 17:58:43 284 18:37:13 00:38:13 115966 116108 143  
124 284 18:37:13 284 21:20:16 02:43:03 116109 116714 606 5 7 38 7.6  
124->149 284 21:20:16 284 21:50:01 00:29:25 116715 116805 91  
Beg 149 284 21:50:01 284 23:59:38 02:09:37 116806 117279 474

**Summary Julian Day 285 October 12th**

End 149 285 00:00:10 285 00:31:19 00:31:09 117281 117403 123  
149->126 285 00:31:19 285 01:12:08 00:40:31 117404 117541 138  
126 285 01:12:08 285 04:19:60 03:07:51 117542 118146 605 5 13 38 4.0  
126->151 285 04:19:60 285 04:47:17 00:26:59 118147 118231 85  
151 285 04:47:17 285 07:27:24 02:40:08 118232 118833 602 -4 13 38 -5.8  
151->128 285 07:27:24 285 07:59:42 00:31:58 118834 118942 109  
128 285 07:59:42 285 11:16:10 03:16:28 118943 119547 605 2 9 38 4.9  
128->153 285 11:16:10 285 12:02:30 00:46:04 119548 119691 144  
153 285 12:02:30 285 14:36:30 02:34:00 119692 120298 607 2 14 38 -1.4  
153->130 285 14:36:30 285 15:10:35 00:33:43 120299 120410 112  
130 285 15:10:35 285 18:32:11 03:21:37 120411 121015 605 -7 6 38 -6.3  
130->155 285 18:32:11 285 19:09:37 00:37:10 121016 121134 119  
155 285 19:09:37 285 21:48:28 02:38:51 121135 121741 607 15 19 38 11.1  
155->180 285 21:48:28 285 22:25:45 00:36:57 121742 121870 129  
Beg 180 285 22:25:45 285 23:59:22 01:33:37 121871 122153 283

**Summary Julian Day 286 October 13th**

End 180 286 00:00:01 286 01:45:55 01:45:54 122155 122475 321  
180->157 286 01:45:55 286 02:59:12 01:13:01 122476 122696 221  
157 286 02:59:12 286 05:47:27 02:48:15 122697 123304 608 18 21 38 15.8  
157->182 286 05:47:27 286 06:24:29 00:36:46 123305 123434 130  
182 286 06:24:29 286 09:05:06 02:40:37 123435 124039 605 -9 9 38 -10.1  
182->159 286 09:05:06 286 09:45:52 00:40:24 124040 124164 125  
159 286 09:45:52 286 12:54:49 03:08:58 124165 124767 603 -4 17 38 12.0  
159->184 286 12:54:49 286 13:31:10 00:36:03 124768 124888 121  
184 286 13:31:10 286 16:13:16 02:42:06 124889 125492 604 -8 8 38 -7.9  
184->161 286 16:13:16 286 16:57:09 00:43:35 125493 125639 147  
161 286 16:57:09 286 20:05:59 03:08:50 125640 126246 607 4 8 38 5.1  
161->186 286 20:05:59 286 20:51:13 00:44:58 126247 126394 148  
186 286 20:51:13 286 23:28:06 02:36:53 126395 126999 605 -3 6 38 -3.6  
Beg->163 286 23:28:06 286 23:59:46 00:31:20 127000 127108 109



**Summary Julian Day 287 October 14th**

End->163 287 00:00:06 287 00:00:46 00:00:20 127111 127111 1  
163 287 00:00:46 287 03:21:33 03:20:46 127112 127716 605 4 12 38 2.4  
163->188 287 03:21:33 287 04:04:07 00:42:17 127717 127848 132  
188 287 04:04:07 287 06:41:43 02:37:36 127849 128452 604 0 6 38 0.2  
188->165 287 06:41:43 287 07:13:34 00:31:30 128453 128560 108  
165 287 07:13:34 287 10:26:07 03:12:33 128561 129166 606 0 4 38 -1.6  
165->190 287 10:26:07 287 11:11:12 00:44:49 129167 129304 138  
190 287 11:11:12 287 13:47:00 02:35:48 129305 129909 605 7 6 38 7.1  
190->167 287 13:47:00 287 14:14:34 00:27:14 129910 130004 95  
167 287 14:14:34 287 17:06:54 02:52:20 130005 130608 604 -3 12 38 -5.6  
167->192 287 17:06:54 287 17:37:25 00:30:12 130609 130707 99  
Abort192 287 17:37:25 287 18:14:17 00:36:52 130708 131001  
Retur192 287 18:14:34 287 19:50:25 01:35:33 131003 131312 310  
192 287 19:50:25 287 22:29:34 02:39:09 131313 131916 604 4 7 38 3.8  
192->169 287 22:29:34 287 22:55:44 00:25:50 131917 132004 88  
Beg 169 287 22:55:44 287 23:59:43 01:03:59 132005 132236 232

**Summary Julian Day 288 October 15th**

End 169 288 00:00:16 288 01:40:10 01:39:53 132238 132606 369  
169->194 288 01:40:10 288 02:19:40 00:39:11 132607 132737 131  
194 288 02:19:40 288 05:14:37 02:54:57 132738 133343 606 3 6 38 4.3  
194->171 288 05:14:37 288 05:46:16 00:31:20 133344 133442 99  
171 288 05:46:16 288 08:25:44 02:39:29 133443 134044 602 -3 7 38 -3.3  
171->196 288 08:25:44 288 08:55:30 00:29:25 134045 134142 98  
196 288 08:55:30 288 11:46:54 02:51:24 134143 134742 600 4 7 39 5.0  
196->173 288 11:46:54 288 12:12:09 00:24:51 134743 134822 80  
173 288 12:12:09 288 14:53:03 02:40:55 134823 135417 595 -2 27 40 -1.4  
173->198 288 14:53:03 288 15:24:08 00:30:45 135418 135522 105  
198 288 15:24:08 288 18:28:14 03:04:06 135523 136127 605 0 5 38 0.7  
198->175 288 18:28:14 288 19:07:25 00:38:51 136128 136241 114  
175 288 19:07:25 288 21:45:56 02:38:31 136242 136845 604 5 7 40 1.3  
175->200 288 21:45:56 288 22:14:26 00:28:12 136846 136943 98  
Beg 200 288 22:14:26 288 23:59:34 01:45:08 136944 137313 370

**Summary Julian Day 289 October 16th**

End 200 289 00:00:08 289 01:07:44 01:07:36 137315 137547 233  
200->177 289 01:07:44 289 01:40:02 00:32:01 137548 137648 101  
177 289 01:40:02 289 04:18:33 02:38:31 137649 138252 604 3 12 38 2.4  
177->154 289 04:18:33 289 04:48:04 00:29:11 138253 138350 98  
154 289 04:48:04 289 07:48:09 03:00:05 138351 138954 604 -4 8 38 -2.9  
154->179 289 07:48:09 289 08:24:09 00:35:43 138955 139075 121  
179 289 08:24:09 289 11:11:16 02:47:07 139076 139681 606 6 11 38 3.7  
179->156 289 11:11:16 289 11:37:07 00:25:32 139682 139762 81  
156 289 11:37:07 289 14:31:24 02:54:16 139763 140366 604 -4 7 38 -4.4  
156->181 289 14:31:24 289 15:10:47 00:39:06 140367 140497 131  
181 289 15:10:47 289 17:53:45 02:42:58 140498 141103 606 7 8 38 5.7  
181->158 289 17:53:45 289 18:27:40 00:33:35 141104 141211 108  
158 289 18:27:40 289 21:11:48 02:44:09 141212 141814 603 -6 9 38 -5.3  
158->183 289 21:11:48 289 21:48:19 00:36:13 141815 141941 127  
Beg 183 289 21:48:19 289 23:59:28 02:11:08 141942 142393 452



**Summary Julian Day 290 October 17th**

End 183 290 00:00:02 290 00:43:25 00:43:23 142395 142546 152  
183->160 290 00:43:25 290 01:20:35 00:36:50 142547 142663 117  
160 290 01:20:35 290 03:59:20 02:38:45 142664 143265 602 -3 8 38 -1.8  
160->185 290 03:59:20 290 04:35:39 00:36:19 143265 143392 128  
185 290 04:35:58 290 07:33:20 02:57:22 143394 143998 605 6 7 38 3.6  
185->162 290 07:33:20 290 08:11:14 00:37:36 143999 144115 117  
162 290 08:11:14 290 10:50:01 02:38:48 144116 144719 604 -5 9 38 -4.4  
162->187 290 10:50:01 290 11:29:25 00:39:05 144720 144854 135  
187 290 11:29:25 290 14:36:44 03:07:19 144855 145459 605 2 8 38 0.3  
187->164 290 14:36:44 290 15:19:26 00:42:25 145460 145598 139  
164 290 15:19:26 290 18:05:37 02:46:11 145599 146202 604 3 6 38 1.9  
164->189 290 18:05:37 290 18:43:09 00:37:13 146203 146327 125  
189 290 18:43:09 290 21:39:35 02:56:26 146328 146932 605 -1 5 38 -3.5  
189->170 290 21:39:35 290 22:18:43 00:38:51 146933 147056 124  
Beg 170 290 22:18:43 290 23:59:42 01:40:59 147057 147433 377

**Summary Julian Day 291 October 18th**

End 170 291 00:00:14 291 00:58:46 00:58:33 147435 147659 225  
170->191 291 00:58:46 291 01:32:40 00:33:35 147660 147772 113  
191 291 01:32:40 291 04:27:54 02:55:14 147773 148378 606 -1 6 38 -4.1  
191->172 291 04:27:54 291 05:01:46 00:33:34 148379 148488 110  
172 291 05:01:46 291 07:48:35 02:46:49 148489 149094 606 3 7 38 3.9  
172->193 291 07:48:35 291 08:26:03 00:37:10 149095 149217 123  
193 291 08:26:03 291 11:18:11 02:52:08 149218 149822 605 -1 5 38 -2.7  
193->174 291 11:18:11 291 11:57:38 00:39:09 149823 149947 125  
174 291 11:57:38 291 14:55:14 02:57:37 149948 150552 605 2 8 38 2.9  
174->195 291 14:55:14 291 15:32:41 00:37:09 150553 150670 118  
195 291 15:32:41 291 18:12:13 02:39:31 150671 151273 603 0 6 39 -2.6  
195->176 291 18:12:13 291 18:50:36 00:38:05 151274 151378 105  
176 291 18:50:36 291 22:01:56 03:11:20 151379 151983 605 1 5 38 1.1  
176->197 291 22:01:56 291 22:46:36 00:44:24 151984 152118 135  
Beg 197 291 22:46:36 291 23:59:43 01:13:07 152119 152402 284

**Summary Julian Day 292 October 19th**

End 197 292 00:00:14 292 01:23:02 01:22:48 152404 152725 322  
197->178 292 01:23:02 292 01:55:12 00:31:48 152726 152825 100  
178 292 01:55:12 292 04:51:25 02:56:13 152826 153426 601 -2 7 38 -1.1  
178->2124 292 04:51:25 292 06:11:38 01:19:53 153427 153696 270  
2124 292 06:11:38 292 09:22:28 03:10:51 153697 154402 706 5 6 38 3.5  
2124->2091 292 09:22:28 292 10:24:58 01:02:11 154403 154614 212  
2091 292 10:24:58 292 13:33:47 03:08:48 154615 155322 708 -4 10 38 -4.8  
2091->2130 292 13:33:47 292 14:39:56 01:05:52 155323 155564 242  
2130 292 14:39:56 292 17:55:43 03:15:47 155565 156271 707 -53 33 39 2.9  
2130->2096 292 17:55:43 292 18:48:29 00:52:25 156272 156454 183  
2096 292 18:48:29 292 22:14:37 03:26:09 156455 157160 706 65 42 39 -2.4  
2096->2071 292 22:14:37 292 23:08:26 00:53:28 157161 157332 172  
Beg 2071 292 23:08:26 292 23:59:32 00:51:06 157333 157517 185



**Summary Julian Day 293 October 20th**

End 2071 293 00:00:06 293 02:18:23 02:18:16 157519 158011 493  
2071->2027 293 02:18:23 293 03:21:35 01:02:54 158012 158234 223  
2027 293 03:21:35 293 06:22:01 03:00:26 158235 158914 680 27 46 38 2.5  
2027->2114 293 06:22:01 293 08:00:07 01:37:49 158915 159258 344  
2114 293 08:00:07 293 10:51:46 02:51:39 159259 159863 605 -22 26 38 0.4  
2114->2149 293 10:51:46 293 11:25:50 00:33:46 159864 159983 120  
2149 293 11:25:50 293 12:01:48 00:35:58 159984 160121 138 -3 4 39 12.8



**Appendix 13**  
**ARAD Line Order Summary**



| Line # | Start | Time     | End | Time     | Duration | 1st Shot | Last Shot | # of Shots | XTE(M)<br>Min | XTE(m)<br>SIG | DX | Feath<br>° |
|--------|-------|----------|-----|----------|----------|----------|-----------|------------|---------------|---------------|----|------------|
| 1      | 265   | 5:16:04  | 265 | 8:02:14  | 2:46:10  | 13969    | 14574     | 606        | 4             | 6             | 38 | 1.9        |
| 2      | 269   | 22:34:23 | 270 | 1:07:44  | 2:33:21  | 38677    | 39280     | 604        | -5            | 13            | 38 | -0.7       |
| 3      | 263   | 3:02:16  | 263 | 5:48:56  | 2:46:40  | 7744     | 8348      | 605        | 10            | 9             | 38 | 7.5        |
| 4      | 270   | 5:23:33  | 270 | 7:58:58  | 2:35:26  | 40157    | 40760     | 604        | -3            | 12            | 38 | -1.1       |
| 5      | 265   | 12:29:08 | 265 | 15:16:09 | 2:47:00  | 15517    | 16121     | 605        | 2             | 5             | 38 | 0.1        |
| 6      | 270   | 12:09:38 | 270 | 14:48:04 | 2:38:25  | 41651    | 42253     | 603        | 0             | 10            | 38 | 0.3        |
| 7      | 265   | 19:21:12 | 265 | 22:06:21 | 2:45:09  | 16991    | 17591     | 601        | 3             | 14            | 38 | 0.2        |
| 8      | 270   | 18:59:53 | 270 | 21:37:24 | 2:37:31  | 43139    | 43741     | 603        | 2             | 6             | 38 | 2          |
| 9      | 266   | 2:04:26  | 266 | 4:48:45  | 2:44:19  | 18440    | 19041     | 602        | 3             | 8             | 39 | -0.2       |
| 10     | 271   | 1:33:57  | 271 | 4:13:51  | 2:39:54  | 44622    | 45220     | 599        | -2            | 6             | 39 | -0.9       |
| 11     | 266   | 8:47:30  | 266 | 11:34:45 | 2:47:15  | 19889    | 20492     | 604        | 7             | 12            | 38 | 3.4        |
| 12     | 271   | 8:07:09  | 271 | 10:47:41 | 2:40:31  | 46089    | 46690     | 602        | -4            | 6             | 38 | -4.4       |
| 13     | 266   | 15:41:13 | 266 | 18:20:33 | 2:39:21  | 21396    | 22001     | 606        | 9             | 8             | 38 | 6.9        |
| 14     | 271   | 14:49:59 | 271 | 17:31:37 | 2:41:37  | 47579    | 48182     | 604        | -8            | 16            | 38 | -7         |
| 15     | 266   | 22:20:14 | 267 | 1:00:54  | 2:40:41  | 22885    | 23488     | 604        | 15            | 17            | 39 | 10.2       |
| 16     | 271   | 21:30:35 | 272 | 0:11:19  | 2:40:44  | 49053    | 49657     | 605        | -11           | 11            | 38 | -11.6      |
| 17     | 267   | 5:24:48  | 267 | 8:15:16  | 2:50:29  | 24458    | 25063     | 606        | 7             | 8             | 39 | 4.7        |
| 18     | 272   | 4:22:18  | 272 | 7:00:42  | 2:38:24  | 50550    | 51149     | 600        | -5            | 21            | 39 | -4.9       |
| 19     | 267   | 12:23:07 | 267 | 15:12:34 | 2:49:27  | 25959    | 26563     | 605        | 2             | 9             | 39 | 1.9        |
| 20     | 272   | 11:14:41 | 272 | 13:51:17 | 2:36:36  | 52050    | 52652     | 603        | -4            | 6             | 38 | -4.6       |
| 21     | 267   | 19:05:17 | 267 | 21:49:38 | 2:44:21  | 27418    | 28019     | 602        | 4             | 6             | 38 | 1.5        |
| 22     | 272   | 18:04:47 | 272 | 20:40:36 | 2:35:49  | 53543    | 54146     | 604        | 3             | 16            | 38 | -4.2       |
| 23     | 268   | 1:54:26  | 268 | 4:34:26  | 2:40:01  | 28899    | 29502     | 604        | 9             | 15            | 38 | 2.3        |
| 24     | 273   | 0:49:53  | 273 | 3:29:24  | 2:39:32  | 55030    | 55632     | 603        | -4            | 8             | 38 | -4.5       |
| 25     | 268   | 8:36:58  | 268 | 11:14:02 | 2:37:04  | 30403    | 31006     | 604        | 6             | 11            | 38 | 3          |
| 26     | 273   | 7:33:35  | 273 | 10:12:17 | 2:38:42  | 56510    | 57112     | 603        | 6             | 15            | 38 | 3.1        |
| 27     | 268   | 15:25:34 | 268 | 18:07:45 | 2:42:11  | 31927    | 32532     | 606        | 12            | 24            | 38 | 10.1       |
| 28     | 273   | 14:11:10 | 273 | 16:51:15 | 2:40:05  | 57985    | 58586     | 602        | -1            | 7             | 38 | -1.2       |
| 29     | 268   | 22:17:55 | 269 | 1:10:54  | 2:52:59  | 33458    | 34062     | 605        | 8             | 18            | 38 | 4.4        |
| 30     | 273   | 20:48:16 | 273 | 23:24:59 | 2:36:43  | 59457    | 60058     | 602        | -3            | 7             | 38 | -3.3       |
| 31     | 269   | 5:25:06  | 269 | 8:14:23  | 2:49:17  | 34988    | 35594     | 607        | 7             | 8             | 38 | 6.3        |
| 32     | 265   | 8:39:21  | 265 | 11:26:17 | 2:46:56  | 14700    | 15302     | 603        | 1             | 9             | 38 | -1.5       |
| 33     | 269   | 12:20:33 | 269 | 15:17:18 | 2:56:44  | 36495    | 37099     | 605        | 7             | 17            | 38 | 5.3        |
| 34     | 265   | 1:34:21  | 265 | 4:18:05  | 2:43:44  | 13165    | 13766     | 602        | -1            | 14            | 38 | -2.4       |
| 35     | 269   | 19:08:28 | 269 | 22:00:52 | 2:52:23  | 37957    | 38559     | 603        | 3             | 7             | 38 | 1.4        |
| 36     | 262   | 23:31:07 | 263 | 2:15:10  | 2:44:03  | 6977     | 7579      | 603        | -1            | 13            | 39 | 0.4        |
| 37     | 270   | 1:51:26  | 270 | 4:50:12  | 2:58:46  | 39437    | 40041     | 605        | 2             | 9             | 38 | 2.4        |
| 38     | 265   | 15:54:24 | 265 | 18:40:36 | 2:46:12  | 16252    | 16855     | 604        | 4             | 12            | 38 | 2.8        |
| 39     | 270   | 8:40:15  | 270 | 11:28:37 | 2:48:23  | 40907    | 41509     | 603        | -9            | 6             | 38 | -2.5       |
| 40     | 265   | 22:40:52 | 266 | 1:27:18  | 2:46:26  | 17711    | 18315     | 605        | -3            | 8             | 38 | -0.6       |
| 41     | 270   | 15:28:30 | 270 | 18:20:30 | 2:52:00  | 42398    | 42999     | 602        | 0             | 8             | 38 | -0.8       |
| 42     | 266   | 5:27:37  | 266 | 8:14:51  | 2:47:13  | 19176    | 19781     | 606        | -4            | 5             | 38 | -2.1       |
| 43     | 270   | 22:15:09 | 271 | 0:52:54  | 2:37:45  | 43879    | 44482     | 604        | 0             | 6             | 38 | -2.7       |
| 44     | 266   | 12:14:08 | 266 | 14:54:46 | 2:40:38  | 20628    | 21229     | 602        | -4            | 6             | 38 | -2.9       |
| 45     | 271   | 4:50:26  | 271 | 7:29:18  | 2:38:53  | 45353    | 45957     | 605        | 9             | 11            | 38 | 3.3        |
| 46     | 266   | 19:06:18 | 266 | 21:43:47 | 2:37:30  | 22160    | 22760     | 601        | -8            | 11            | 39 | -7.8       |
| 47     | 271   | 11:26:08 | 271 | 14:06:41 | 2:40:33  | 46828    | 47430     | 603        | 9             | 9             | 38 | 2.9        |
| 48     | 267   | 1:57:27  | 267 | 4:36:25  | 2:38:59  | 23683    | 24285     | 603        | -6            | 13            | 39 | -10.1      |
| 49     | 271   | 18:08:41 | 271 | 20:50:05 | 2:41:24  | 48316    | 48918     | 603        | 13            | 17            | 40 | 7.7        |
| 50     | 267   | 9:07:11  | 267 | 11:48:25 | 2:41:15  | 25241    | 25846     | 606        | -5            | 8             | 38 | -3.8       |
| 51     | 272   | 0:54:42  | 272 | 3:42:45  | 2:48:03  | 49816    | 50420     | 605        | 12            | 19            | 38 | 8.9        |
| 52     | 267   | 15:49:03 | 267 | 18:27:42 | 2:38:38  | 26688    | 27291     | 604        | 1             | 12            | 38 | 1.5        |
| 53     | 272   | 7:42:38  | 272 | 10:33:11 | 2:50:33  | 51303    | 51906     | 604        | 7             | 8             | 38 | 4.9        |
| 54     | 267   | 22:38:45 | 268 | 1:19:34  | 2:40:49  | 28183    | 28783     | 601        | -2            | 6             | 38 | -1.6       |
| 55     | 272   | 14:36:32 | 272 | 17:28:20 | 2:51:48  | 52817    | 53420     | 604        | 7             | 15            | 38 | 4.1        |
| 56     | 268   | 5:23:40  | 268 | 8:01:37  | 2:37:57  | 29679    | 30281     | 603        | -2            | 11            | 38 | -1         |
| 57     | 272   | 21:19:37 | 273 | 0:07:24  | 2:47:47  | 54283    | 54886     | 604        | 3             | 7             | 38 | -0.5       |
| 58     | 268   | 11:54:25 | 268 | 14:32:44 | 2:38:19  | 31143    | 31745     | 603        | -9            | 14            | 38 | -7.9       |
| 59     | 273   | 4:05:56  | 273 | 6:53:35  | 2:47:39  | 55764    | 56371     | 608        | 0             | 9             | 38 | -1.6       |
| 60     | 269   | 1:44:14  | 269 | 4:24:52  | 2:40:38  | 34176    | 34777     | 602        | -12           | 21            | 38 | -8         |
| 61     | 273   | 10:50:16 | 273 | 13:32:32 | 2:42:16  | 57248    | 57850     | 603        | 2             | 7             | 38 | -2.3       |
| 62     | 268   | 19:01:45 | 268 | 21:39:20 | 2:37:35  | 32724    | 33325     | 602        | -10           | 13            | 39 | -8.3       |
| 63     | 273   | 17:28:28 | 273 | 20:09:20 | 2:40:52  | 58720    | 59323     | 604        | 5             | 11            | 38 | 2.8        |



|     |     |          |     |          |         |        |        |     |     |    |    |       |
|-----|-----|----------|-----|----------|---------|--------|--------|-----|-----|----|----|-------|
| 64  | 269 | 9:03:04  | 269 | 11:40:59 | 2:37:55 | 35763  | 36367  | 605 | -8  | 14 | 38 | -5.2  |
| 65  | 274 | 0:02:30  | 274 | 2:38:33  | 2:36:03 | 60197  | 60800  | 604 | 6   | 6  | 38 | 2.9   |
| 66  | 269 | 15:50:55 | 269 | 18:28:54 | 2:37:59 | 37216  | 37820  | 605 | -1  | 23 | 39 | -2.4  |
| 67  | 264 | 22:01:50 | 265 | 0:50:13  | 2:48:24 | 12412  | 13016  | 605 | 5   | 6  | 38 | 2.4   |
| 68  | 276 | 20:04:30 | 276 | 22:41:31 | 2:37:01 | 75255  | 75858  | 604 | -1  | 6  | 38 | -2.3  |
| 69  | 262 | 19:35:35 | 262 | 22:16:54 | 2:41:19 | 6118   | 6721   | 604 | 1   | 14 | 39 | 0.3   |
| 70  | 277 | 2:30:03  | 277 | 5:09:19  | 2:39:17 | 76689  | 77292  | 604 | 3   | 8  | 38 | 2     |
| 71  | 274 | 6:15:02  | 274 | 8:57:38  | 2:42:35 | 61585  | 62185  | 601 | 5   | 7  | 39 | 5.6   |
| 72  | 277 | 8:49:20  | 277 | 11:28:26 | 2:39:06 | 78110  | 78712  | 603 | -1  | 7  | 38 | -1.5  |
| 73  | 274 | 12:44:11 | 274 | 15:24:55 | 2:40:44 | 63008  | 63610  | 603 | 7   | 6  | 38 | 4.6   |
| 74  | 277 | 16:53:06 | 277 | 19:35:06 | 2:41:59 | 79900  | 80506  | 607 | -5  | 6  | 38 | -3.8  |
| 75  | 274 | 19:15:57 | 274 | 21:58:44 | 2:42:47 | 64441  | 65045  | 605 | 2   | 6  | 38 | 0.1   |
| 76  | 277 | 23:09:19 | 278 | 1:46:37  | 2:37:18 | 81295  | 81896  | 602 | -4  | 8  | 38 | -2.9  |
| 77  | 275 | 1:44:08  | 275 | 4:24:41  | 2:40:34 | 65860  | 66464  | 605 | 6   | 6  | 38 | 3.9   |
| 78  | 278 | 5:15:59  | 278 | 7:53:41  | 2:37:43 | 82671  | 83270  | 600 | -8  | 13 | 39 | -8.3  |
| 79  | 275 | 8:07:51  | 275 | 10:49:26 | 2:41:35 | 67287  | 67891  | 605 | 3   | 6  | 38 | 2.2   |
| 80  | 278 | 11:47:34 | 278 | 14:27:18 | 2:39:44 | 84122  | 84727  | 606 | -4  | 10 | 38 | -2    |
| 81  | 275 | 14:31:13 | 275 | 17:10:09 | 2:38:56 | 68705  | 69308  | 604 | 6   | 5  | 38 | 4.4   |
| 82  | 278 | 17:55:52 | 278 | 20:33:18 | 2:37:26 | 85501  | 86100  | 600 | -7  | 9  | 39 | -6.5  |
| 83  | 275 | 20:41:37 | 275 | 23:22:32 | 2:40:56 | 70081  | 70683  | 603 | 3   | 6  | 38 | 2.9   |
| 84  | 279 | 2:40:19  | 279 | 5:19:04  | 2:38:46 | 87430  | 88034  | 605 | -3  | 6  | 38 | -3.7  |
| 85  | 276 | 4:08:37  | 276 | 6:55:12  | 2:46:35 | 71761  | 72364  | 604 | 8   | 7  | 38 | 7     |
| 86  | 279 | 8:51:49  | 279 | 11:28:06 | 2:36:17 | 88816  | 89415  | 600 | -4  | 8  | 39 | -5.8  |
| 87  | 276 | 10:31:35 | 276 | 13:25:05 | 2:53:30 | 73172  | 73774  | 603 | 2   | 5  | 38 | 0     |
| 88  | 274 | 3:10:27  | 274 | 5:51:20  | 2:40:52 | 60908  | 61508  | 601 | -7  | 7  | 38 | -5.9  |
| 89  | 276 | 16:55:43 | 276 | 19:33:53 | 2:38:10 | 74549  | 75151  | 603 | 4   | 5  | 38 | 2.5   |
| 90  | 274 | 9:22:21  | 274 | 11:03:03 | 1:40:41 | 62266  | 62641  | 376 | -1  | 13 | 39 | -0.4  |
| 91  | 276 | 23:09:14 | 277 | 1:49:47  | 2:40:34 | 75953  | 76554  | 602 | -2  | 9  | 38 | -4.2  |
| 92  | 274 | 16:04:01 | 274 | 18:45:25 | 2:41:25 | 63739  | 64343  | 605 | -5  | 7  | 38 | -5.3  |
| 93  | 277 | 5:43:52  | 277 | 8:21:51  | 2:37:59 | 77413  | 78017  | 605 | 3   | 5  | 38 | -0.3  |
| 94  | 274 | 22:33:56 | 275 | 1:13:55  | 2:39:59 | 65157  | 65759  | 603 | -2  | 10 | 38 | 1.3   |
| 95  | 277 | 11:54:16 | 277 | 14:31:55 | 2:37:40 | 78800  | 79402  | 603 | -1  | 5  | 38 | -3.2  |
| 96  | 275 | 4:59:48  | 275 | 7:37:46  | 2:37:59 | 66583  | 67186  | 604 | -5  | 5  | 38 | -4.7  |
| 97  | 277 | 19:57:30 | 277 | 22:36:46 | 2:39:17 | 80584  | 81186  | 603 | 8   | 12 | 38 | 4.5   |
| 98  | 275 | 11:20:20 | 275 | 13:59:09 | 2:38:50 | 67994  | 68598  | 605 | -2  | 5  | 38 | 0     |
| 99  | 278 | 2:12:36  | 278 | 4:50:29  | 2:37:53 | 81987  | 82587  | 601 | 10  | 6  | 38 | 3.4   |
| 100 | 264 | 18:29:48 | 264 | 21:15:23 | 2:45:35 | 11647  | 12250  | 604 | -1  | 12 | 38 | -2.7  |
| 101 | 278 | 8:23:26  | 278 | 11:05:32 | 2:42:06 | 83378  | 83981  | 604 | 8   | 13 | 38 | 5.5   |
| 102 | 262 | 16:06:19 | 262 | 18:55:09 | 2:48:51 | 5380   | 5980   | 601 | -3  | 10 | 39 | -3.1  |
| 103 | 278 | 14:53:15 | 278 | 17:31:14 | 2:37:59 | 84817  | 85418  | 602 | 7   | 8  | 38 | 3.8   |
| 104 | 275 | 17:36:13 | 275 | 20:16:24 | 2:40:12 | 69396  | 69997  | 602 | -7  | 7  | 38 | -6.8  |
| 105 | 278 | 23:20:19 | 279 | 2:01:11  | 2:40:52 | 86694  | 87298  | 605 | 3   | 6  | 38 | 1.9   |
| 106 | 276 | 1:04:50  | 276 | 3:42:42  | 2:37:52 | 71068  | 71673  | 606 | -3  | 7  | 38 | -0.1  |
| 107 | 279 | 5:47:56  | 279 | 8:27:54  | 2:39:58 | 88135  | 88738  | 604 | 9   | 9  | 38 | 5.4   |
| 108 | 276 | 7:25:59  | 276 | 10:03:38 | 2:37:38 | 72472  | 73076  | 605 | -6  | 12 | 38 | -6.1  |
| 109 | 279 | 11:54:44 | 279 | 14:35:41 | 2:40:57 | 89510  | 90111  | 602 | 2   | 7  | 38 | 0.5   |
| 110 | 276 | 13:52:28 | 276 | 16:30:14 | 2:37:46 | 73862  | 74461  | 600 | 0   | 17 | 39 | 0.6   |
| 111 | 279 | 18:11:23 | 279 | 20:51:10 | 2:39:47 | 90903  | 91505  | 603 | 5   | 5  | 40 | 2.6   |
| 112 | 282 | 21:33:20 | 283 | 0:53:06  | 3:19:46 | 106893 | 107501 | 609 | -3  | 10 | 38 | -2    |
| 113 | 280 | 1:32:17  | 280 | 4:09:58  | 2:37:41 | 92540  | 93140  | 601 | 2   | 7  | 38 | -0.4  |
| 114 | 283 | 4:43:23  | 283 | 7:58:03  | 3:14:40 | 108341 | 108947 | 607 | -7  | 5  | 38 | -6.3  |
| 115 | 280 | 11:04:31 | 280 | 13:48:41 | 2:44:10 | 94623  | 95227  | 605 | 3   | 29 | 38 | 3.7   |
| 116 | 283 | 14:23:38 | 283 | 17:16:35 | 2:52:57 | 110305 | 110904 | 600 | -11 | 9  | 39 | -10.1 |
| 117 | 280 | 17:43:55 | 280 | 20:25:42 | 2:41:47 | 96026  | 96628  | 603 | 14  | 17 | 38 | 9.4   |
| 118 | 283 | 21:41:06 | 284 | 0:19:55  | 2:38:49 | 111787 | 112389 | 603 | -9  | 13 | 38 | -11.2 |
| 119 | 281 | 0:06:05  | 281 | 3:08:30  | 3:02:25 | 97407  | 98011  | 605 | 12  | 15 | 38 | 8.6   |
| 120 | 284 | 4:33:45  | 284 | 7:13:36  | 2:39:51 | 113206 | 113808 | 603 | -4  | 7  | 38 | -4.5  |
| 121 | 281 | 6:49:59  | 281 | 9:45:14  | 2:55:15 | 98801  | 99402  | 602 | 6   | 10 | 38 | 4.5   |
| 122 | 284 | 11:46:16 | 284 | 14:26:11 | 2:39:56 | 114661 | 115266 | 606 | 0   | 6  | 38 | 1.3   |
| 123 | 281 | 13:26:15 | 281 | 16:17:40 | 2:51:24 | 100202 | 100803 | 602 | -2  | 12 | 38 | -1.2  |
| 124 | 284 | 18:37:13 | 284 | 21:20:16 | 2:43:03 | 116109 | 116714 | 606 | 5   | 7  | 38 | 7.6   |
| 125 | 281 | 21:51:22 | 282 | 0:44:59  | 2:53:37 | 101967 | 102568 | 602 | 4   | 5  | 38 | 2.6   |
| 126 | 285 | 1:12:08  | 285 | 4:19:59  | 3:07:51 | 117542 | 118146 | 605 | 5   | 13 | 38 | 4     |
| 127 | 282 | 4:34:18  | 282 | 7:23:38  | 2:49:20 | 103355 | 103959 | 605 | 6   | 7  | 38 | 4.7   |
| 128 | 285 | 7:59:42  | 285 | 11:16:10 | 3:16:28 | 118943 | 119547 | 605 | 2   | 9  | 38 | 4.9   |



|     |     |          |     |          |         |        |        |     |     |    |    |       |
|-----|-----|----------|-----|----------|---------|--------|--------|-----|-----|----|----|-------|
| 129 | 282 | 11:07:47 | 282 | 13:55:51 | 2:48:03 | 104725 | 105324 | 600 | 0   | 12 | 39 | -2    |
| 130 | 285 | 15:10:35 | 285 | 18:32:11 | 3:21:37 | 120411 | 121015 | 605 | -7  | 6  | 38 | -6.3  |
| 131 | 282 | 18:08:42 | 282 | 20:54:40 | 2:45:58 | 106166 | 106768 | 603 | 2   | 11 | 38 | 1.2   |
| 132 | 279 | 15:06:24 | 279 | 17:46:25 | 2:40:02 | 90216  | 90817  | 602 | -1  | 6  | 38 | -0.3  |
| 133 | 264 | 14:49:48 | 264 | 17:35:13 | 2:45:25 | 10857  | 11459  | 603 | 6   | 8  | 38 | 4.1   |
| 134 | 279 | 21:17:13 | 279 | 23:54:56 | 2:37:43 | 91592  | 92195  | 604 | -4  | 8  | 38 | -1.5  |
| 135 | 262 | 12:28:30 | 262 | 15:13:36 | 2:45:07 | 4608   | 5211   | 604 | 2   | 11 | 38 | -0.6  |
| 136 | 280 | 4:41:53  | 280 | 7:24:09  | 2:42:16 | 93247  | 93848  | 602 | -2  | 6  | 38 | -0.2  |
| 137 | 283 | 1:25:49  | 283 | 4:01:09  | 2:35:21 | 107600 | 108205 | 606 | 2   | 22 | 38 | 3.6   |
| 138 | 280 | 14:20:31 | 280 | 17:14:56 | 2:54:25 | 95334  | 95937  | 604 | -7  | 8  | 38 | -5.1  |
| 139 | 283 | 8:33:49  | 283 | 9:56:36  | 1:22:47 | 109060 | 109369 | 310 | 13  | 18 | 38 | 8     |
| 139 | 283 | 11:55:02 | 283 | 13:53:01 | 1:58:00 | 109766 | 110206 | 441 | 15  | 17 | 38 | 8.9   |
| 140 | 280 | 20:54:32 | 280 | 23:41:30 | 2:46:58 | 96727  | 97329  | 603 | -8  | 19 | 38 | -8.4  |
| 141 | 283 | 18:02:28 | 283 | 21:02:07 | 2:59:39 | 111067 | 111673 | 607 | 13  | 10 | 38 | 10.7  |
| 142 | 281 | 3:39:28  | 281 | 6:21:39  | 2:42:11 | 98110  | 98710  | 601 | -8  | 14 | 39 | -4.9  |
| 143 | 284 | 0:50:28  | 284 | 3:59:01  | 3:08:32 | 112496 | 113100 | 605 | 8   | 11 | 38 | 5     |
| 144 | 281 | 10:18:43 | 281 | 12:59:01 | 2:40:18 | 99510  | 100112 | 603 | -2  | 6  | 38 | -1.4  |
| 145 | 284 | 7:44:26  | 284 | 11:00:07 | 3:15:41 | 113914 | 114517 | 604 | 2   | 5  | 38 | 0.9   |
| 146 | 281 | 18:34:19 | 281 | 21:22:09 | 2:47:50 | 101269 | 101873 | 605 | -3  | 5  | 38 | 0     |
| 147 | 284 | 14:55:14 | 284 | 17:58:43 | 3:03:29 | 115363 | 115965 | 603 | -5  | 9  | 39 | -4.9  |
| 148 | 282 | 1:15:59  | 282 | 4:08:41  | 2:52:42 | 102669 | 103272 | 604 | -3  | 7  | 38 | 0.2   |
| 149 | 284 | 21:50:01 | 285 | 0:31:19  | 2:41:17 | 116806 | 117403 | 598 | -7  | 21 | 39 | -9.5  |
| 150 | 282 | 7:50:43  | 282 | 10:43:30 | 2:52:47 | 104047 | 104649 | 603 | -3  | 7  | 38 | -3.4  |
| 151 | 285 | 4:47:17  | 285 | 7:27:24  | 2:40:08 | 118232 | 118833 | 602 | -4  | 13 | 38 | -5.8  |
| 152 | 282 | 14:29:35 | 282 | 17:29:58 | 3:00:23 | 105437 | 106041 | 605 | 0   | 15 | 38 | -0.2  |
| 153 | 285 | 12:02:30 | 285 | 14:36:30 | 2:34:00 | 119692 | 120298 | 607 | 2   | 14 | 38 | -1.4  |
| 154 | 289 | 4:48:04  | 289 | 7:48:09  | 3:00:05 | 138351 | 138954 | 604 | -4  | 8  | 38 | -2.9  |
| 155 | 285 | 19:09:37 | 285 | 21:48:28 | 2:38:51 | 121135 | 121741 | 607 | 15  | 19 | 38 | 11.1  |
| 156 | 289 | 11:37:07 | 289 | 14:31:24 | 2:54:16 | 139763 | 140366 | 604 | -4  | 7  | 38 | -4.4  |
| 157 | 286 | 2:59:12  | 286 | 5:47:27  | 2:48:15 | 122697 | 123304 | 608 | 18  | 21 | 38 | 15.8  |
| 158 | 289 | 18:27:40 | 289 | 21:11:48 | 2:44:09 | 141212 | 141814 | 603 | -6  | 9  | 38 | -5.3  |
| 159 | 286 | 9:45:52  | 286 | 12:54:49 | 3:08:58 | 124165 | 124767 | 603 | -4  | 17 | 38 | 12    |
| 160 | 290 | 1:20:35  | 290 | 3:59:20  | 2:38:45 | 142664 | 143265 | 602 | -3  | 8  | 38 | -1.8  |
| 161 | 286 | 16:57:09 | 286 | 20:05:59 | 3:08:50 | 125640 | 126246 | 607 | 4   | 8  | 38 | 5.1   |
| 162 | 290 | 8:11:14  | 290 | 10:50:01 | 2:38:48 | 144116 | 144719 | 604 | -5  | 9  | 38 | -4.4  |
| 163 | 287 | 0:00:46  | 287 | 3:21:33  | 3:20:46 | 127112 | 127716 | 605 | 4   | 12 | 38 | 2.4   |
| 164 | 290 | 15:19:26 | 290 | 18:05:37 | 2:46:11 | 145599 | 146202 | 604 | 3   | 6  | 38 | 1.9   |
| 165 | 287 | 7:13:34  | 287 | 10:26:07 | 3:12:33 | 128581 | 129186 | 606 | 0   | 4  | 38 | -1.6  |
| 166 | 264 | 11:13:12 | 264 | 13:58:01 | 2:44:49 | 10074  | 10674  | 601 | -4  | 13 | 39 | -4.3  |
| 167 | 287 | 14:14:34 | 287 | 17:06:54 | 2:52:20 | 130005 | 130608 | 604 | -3  | 12 | 38 | -5.6  |
| 168 | 262 | 8:51:05  | 262 | 11:41:26 | 2:50:21 | 3846   | 4448   | 603 | 3   | 21 | 39 | 0.5   |
| 169 | 287 | 22:55:44 | 288 | 1:40:10  | 2:44:26 | 132005 | 132606 | 602 | -5  | 9  | 38 | -6.5  |
| 170 | 290 | 22:18:43 | 291 | 0:58:46  | 2:40:03 | 147057 | 147659 | 603 | 5   | 6  | 38 | 5.4   |
| 171 | 288 | 5:46:16  | 288 | 8:25:44  | 2:39:29 | 133443 | 134044 | 602 | -3  | 7  | 38 | -3.3  |
| 172 | 291 | 5:01:46  | 291 | 7:48:35  | 2:46:49 | 148489 | 149094 | 606 | 3   | 7  | 38 | 3.9   |
| 173 | 288 | 12:12:09 | 288 | 14:53:03 | 2:40:55 | 134823 | 135417 | 595 | -2  | 27 | 40 | -1.4  |
| 174 | 291 | 11:57:38 | 291 | 14:55:14 | 2:57:37 | 149948 | 150552 | 605 | 2   | 8  | 38 | 2.9   |
| 175 | 288 | 19:07:25 | 288 | 21:45:56 | 2:38:31 | 136242 | 136845 | 604 | 5   | 7  | 40 | 1.3   |
| 176 | 291 | 18:50:36 | 291 | 22:01:56 | 3:11:20 | 151379 | 151983 | 605 | 1   | 5  | 38 | 1.1   |
| 177 | 289 | 1:40:02  | 289 | 4:18:33  | 2:38:31 | 137649 | 138252 | 604 | 3   | 12 | 38 | 2.4   |
| 178 | 292 | 1:55:12  | 292 | 4:51:25  | 2:56:13 | 152826 | 153426 | 601 | -2  | 7  | 38 | -1.1  |
| 179 | 289 | 8:24:09  | 289 | 11:11:16 | 2:47:07 | 139076 | 139681 | 606 | 6   | 11 | 38 | 3.7   |
| 180 | 285 | 22:25:45 | 286 | 1:45:55  | 3:20:10 | 121871 | 122475 | 605 | -15 | 9  | 38 | -13.5 |
| 181 | 289 | 15:10:47 | 289 | 17:53:45 | 2:42:58 | 140498 | 141103 | 606 | 7   | 8  | 38 | 5.7   |
| 182 | 286 | 6:24:29  | 286 | 9:05:06  | 2:40:37 | 123435 | 124039 | 605 | -9  | 9  | 38 | -10.1 |
| 183 | 289 | 21:48:19 | 290 | 0:43:25  | 2:55:06 | 141942 | 142546 | 605 | 4   | 7  | 38 | 5     |
| 184 | 286 | 13:31:10 | 286 | 16:13:16 | 2:42:06 | 124889 | 125492 | 604 | -8  | 8  | 38 | -7.9  |
| 185 | 290 | 4:35:58  | 290 | 7:33:20  | 2:57:22 | 143394 | 143998 | 605 | 6   | 7  | 38 | 3.6   |
| 186 | 286 | 20:51:13 | 286 | 23:28:06 | 2:36:53 | 126395 | 126999 | 605 | -3  | 6  | 38 | -3.6  |
| 187 | 290 | 11:29:25 | 290 | 14:36:44 | 3:07:19 | 144855 | 145459 | 605 | 2   | 8  | 38 | 0.3   |
| 188 | 287 | 4:04:07  | 287 | 6:41:43  | 2:37:36 | 127849 | 128452 | 604 | 0   | 6  | 38 | 0.2   |
| 189 | 290 | 18:43:09 | 290 | 21:39:35 | 2:56:26 | 146328 | 146932 | 605 | -1  | 5  | 38 | -3.5  |
| 190 | 287 | 11:11:12 | 287 | 13:47:00 | 2:35:48 | 129305 | 129909 | 605 | 7   | 6  | 38 | 7.1   |
| 191 | 291 | 1:32:40  | 291 | 4:27:54  | 2:55:14 | 147773 | 148378 | 606 | -1  | 6  | 38 | -4.1  |
| 192 | 287 | 19:50:25 | 287 | 22:29:34 | 2:39:09 | 131313 | 131916 | 604 | 4   | 7  | 38 | 3.8   |



|               |     |          |     |          |         |        |        |     |     |    |    |      |
|---------------|-----|----------|-----|----------|---------|--------|--------|-----|-----|----|----|------|
| 193           | 291 | 8:26:03  | 291 | 11:18:11 | 2:52:08 | 149218 | 149822 | 605 | -1  | 5  | 38 | -2.7 |
| 194           | 288 | 2:19:40  | 288 | 5:14:37  | 2:54:57 | 132738 | 133343 | 606 | 3   | 6  | 38 | 4.3  |
| 195           | 291 | 15:32:41 | 291 | 18:12:13 | 2:39:31 | 150671 | 151273 | 603 | 0   | 6  | 39 | -2.6 |
| 196           | 288 | 8:55:30  | 288 | 11:46:54 | 2:51:24 | 134143 | 134742 | 600 | 4   | 7  | 39 | 5    |
| 197           | 291 | 22:46:36 | 292 | 1:23:02  | 2:36:26 | 152119 | 152725 | 607 | 1   | 9  | 38 | -1.4 |
| 198           | 288 | 15:24:08 | 288 | 18:28:14 | 3:04:06 | 135523 | 136127 | 605 | 0   | 5  | 38 | 0.7  |
| 199           | 264 | 7:35:18  | 264 | 10:23:54 | 2:48:36 | 9298   | 9903   | 606 | 8   | 10 | 38 | 6.1  |
| 200           | 288 | 22:14:26 | 289 | 1:07:44  | 2:53:17 | 136944 | 137547 | 604 | -3  | 11 | 38 | -1.2 |
| 201           | 262 | 5:08:26  | 262 | 8:00:40  | 2:52:14 | 3077   | 3684   | 608 | 2   | 9  | 38 | 3.4  |
| Reshoot Lines |     |          |     |          |         |        |        |     |     |    |    |      |
| 27            | 293 | 3:21:35  | 293 | 6:22:01  | 3:00:26 | 158235 | 158914 | 680 | 27  | 46 | 38 | 2.5  |
| 71            | 292 | 23:08:26 | 293 | 2:18:23  | 3:09:57 | 157333 | 158011 | 679 | -50 | 33 | 42 | 3.9  |
| 91            | 292 | 10:24:58 | 292 | 13:33:47 | 3:08:48 | 154615 | 155322 | 708 | -4  | 10 | 38 | -4.8 |
| 96            | 292 | 18:48:29 | 292 | 22:14:37 | 3:26:09 | 156455 | 157160 | 706 | 65  | 42 | 39 | -2.4 |
| 114           | 293 | 8:00:07  | 293 | 10:51:46 | 2:51:39 | 159259 | 159863 | 605 | -22 | 26 | 38 | 0.4  |
| 124           | 292 | 6:11:38  | 292 | 9:22:28  | 3:10:51 | 153697 | 154402 | 706 | 5   | 6  | 38 | 3.5  |
| 130           | 292 | 14:39:56 | 292 | 17:55:43 | 3:15:47 | 155565 | 156271 | 707 | -53 | 33 | 39 | 2.9  |
| 149           | 293 | 11:25:50 | 293 | 12:01:48 | 0:35:58 | 159984 | 160121 | 138 | -3  | 4  | 39 | 12.8 |



**Appendix 14**  
**ARAD Tape Log**



| Archive File | Line   | 1st Shot# | Last Shot | Tape # |
|--------------|--------|-----------|-----------|--------|
| shot.003080  | ARAD-1 | 3080      | 3191      | 1      |
| shot.003192  | ARAD-1 | 3192      | 3303      | 2      |
| shot.003304  | ARAD-1 | 3304      | 3417      | 3      |
| shot.003418  | ARAD-1 | 3418      | 3529      | 4      |
| shot.003530  | ARAD-1 | 3530      | 3641      | 5      |
| shot.003642  | ARAD-1 | 3642      | 3753      | 6      |
| shot.003754  | ARAD-1 | 3754      | 3865      | 7      |
| shot.003866  | ARAD-1 | 3866      | 3977      | 8      |
| shot.003978  | ARAD-1 | 3978      | 4089      | 9      |
| shot.004090  | ARAD-1 | 4090      | 4201      | 10     |
| shot.004202  | ARAD-1 | 4202      | 4313      | 11     |
| shot.004314  | ARAD-1 | 4314      | 4425      | 12     |
| shot.004426  | ARAD-1 | 4426      | 4537      | 13     |
| shot.004538  | ARAD-1 | 4538      | 4649      | 14     |
| shot.004656  | ARAD-1 | 4656      | 4766      | 21     |
| shot.004767  | ARAD-1 | 4767      | 4878      | 22     |
| shot.004879  | ARAD-1 | 4879      | 4990      | 23     |
| shot.004991  | ARAD-1 | 4991      | 5102      | 24     |
| shot.005103  | ARAD-1 | 5103      | 5214      | 25     |
| shot.005215  | ARAD-1 | 5215      | 5326      | 26     |
| shot.005327  | ARAD-1 | 5327      | 5438      | 27     |
| shot.005439  | ARAD-1 | 5439      | 5550      | 28     |
| shot.005551  | ARAD-1 | 5551      | 5662      | 29     |
| shot.005663  | ARAD-1 | 5663      | 5775      | 30     |
| shot.005776  | ARAD-1 | 5776      | 5886      | 31     |
| shot.005887  | ARAD-1 | 5887      | 5998      | 32     |
| shot.005999  | ARAD-1 | 5999      | 6110      | 33     |
| shot.006111  | ARAD-1 | 6111      | 6222      | 34     |
| shot.006223  | ARAD-1 | 6223      | 6334      | 35     |
| shot.006335  | ARAD-1 | 6335      | 6446      | 36     |
| shot.006447  | ARAD-1 | 6447      | 6558      | 37     |
| shot.006559  | ARAD-1 | 6559      | 6670      | 38     |
| shot.006671  | ARAD-1 | 6671      | 6782      | 39     |
| shot.006783  | ARAD-1 | 6783      | 6894      | 40     |
| shot.006895  | ARAD-1 | 6895      | 7006      | 41     |
| shot.007007  | ARAD-1 | 7007      | 7118      | 42     |
| shot.007127  | ARAD-1 | 7127      | 7236      | 48     |
| shot.007237  | ARAD-1 | 7237      | 7349      | 49     |
| shot.007350  | ARAD-1 | 7350      | 7461      | 50     |
| shot.007462  | ARAD-1 | 7462      | 7573      | 51     |
| shot.007574  | ARAD-1 | 7574      | 7685      | 52     |
| shot.007691  | ARAD-1 | 7691      | 7801      | 58     |
| shot.007802  | ARAD-1 | 7802      | 7914      | 59     |
| shot.007915  | ARAD-1 | 7915      | 8026      | 60     |
| shot.008027  | ARAD-1 | 8027      | 8138      | 61     |



|             |        |       |       |    |
|-------------|--------|-------|-------|----|
| shot.008139 | ARAD-1 | 8139  | 8250  | 62 |
| shot.008251 | ARAD-1 | 8251  | 8362  | 63 |
| shot.008363 | ARAD-1 | 8363  | 8436  | 64 |
| shot.008437 | OBH-MA | 8437  | 8548  | 1  |
| shot.008549 | OBH-MA | 8549  | 8660  | 2  |
| shot.008661 | OBH-MA | 8661  | 8772  | 3  |
| shot.008773 | OBH-MA | 8773  | 8884  | 4  |
| shot.008885 | OBH-MA | 8885  | 8996  | 5  |
| shot.008997 | OBH-MA | 8997  | 9109  | 6  |
| shot.009110 | OBH-MA | 9110  | 9236  | 7  |
| shot.009237 | ARAD-2 | 9237  | 9348  | 1  |
| shot.009349 | ARAD-2 | 9349  | 9460  | 2  |
| shot.009461 | ARAD-2 | 9461  | 9572  | 3  |
| shot.009573 | ARAD-2 | 9573  | 9684  | 4  |
| shot.009685 | ARAD-2 | 9685  | 9796  | 5  |
| shot.009797 | ARAD-2 | 9797  | 9908  | 6  |
| shot.009914 | ARAD-2 | 9914  | 10023 | 10 |
| shot.010024 | ARAD-2 | 10024 | 10135 | 11 |
| shot.010136 | ARAD-2 | 10136 | 10247 | 12 |
| shot.010248 | ARAD-2 | 10248 | 10359 | 13 |
| shot.010360 | ARAD-2 | 10360 | 10471 | 14 |
| shot.010472 | ARAD-2 | 10472 | 10583 | 15 |
| shot.010584 | ARAD-2 | 10584 | 10695 | 16 |
| shot.010696 | ARAD-2 | 10696 | 10807 | 17 |
| shot.010808 | ARAD-2 | 10808 | 10919 | 18 |
| shot.010920 | ARAD-2 | 10920 | 11031 | 19 |
| shot.011032 | ARAD-2 | 11032 | 11143 | 20 |
| shot.011144 | ARAD-2 | 11144 | 11255 | 21 |
| shot.011256 | ARAD-2 | 11256 | 11367 | 22 |
| shot.011368 | ARAD-2 | 11368 | 11479 | 23 |
| shot.011480 | ARAD-2 | 11480 | 11591 | 24 |
| shot.011592 | ARAD-2 | 11592 | 11703 | 25 |
| shot.011704 | ARAD-2 | 11704 | 11815 | 26 |
| shot.011816 | ARAD-2 | 11816 | 11927 | 27 |
| shot.011928 | ARAD-2 | 11928 | 12039 | 28 |
| shot.012040 | ARAD-2 | 12040 | 12151 | 29 |
| shot.012152 | ARAD-2 | 12152 | 12263 | 30 |
| shot.012264 | ARAD-2 | 12264 | 12375 | 31 |
| shot.012376 | ARAD-2 | 12376 | 12487 | 32 |
| shot.012488 | ARAD-2 | 12488 | 12615 | 43 |
| shot.012616 | ARAD-2 | 12616 | 12727 | 44 |
| shot.012728 | ARAD-2 | 12728 | 12839 | 45 |
| shot.012840 | ARAD-2 | 12840 | 12951 | 46 |
| shot.012952 | ARAD-2 | 12952 | 13063 | 47 |
| shot.013064 | ARAD-2 | 13064 | 13175 | 48 |
| shot.013176 | ARAD-2 | 13176 | 13287 | 49 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.013288 | ARAD-2 | 13288 | 13399 | 50  |
| shot.013400 | ARAD-2 | 13400 | 13511 | 51  |
| shot.013512 | ARAD-2 | 13512 | 13623 | 52  |
| shot.013624 | ARAD-2 | 13624 | 13735 | 53  |
| shot.013736 | ARAD-2 | 13736 | 13847 | 54  |
| shot.013848 | ARAD-2 | 13848 | 13959 | 55  |
| shot.013960 | ARAD-2 | 13960 | 14071 | 56  |
| shot.014072 | ARAD-2 | 14072 | 14183 | 57  |
| shot.014184 | ARAD-2 | 14184 | 14295 | 58  |
| shot.014302 | ARAD-2 | 14302 | 14411 | 63  |
| shot.014412 | ARAD-2 | 14412 | 14524 | 64  |
| shot.014525 | ARAD-2 | 14525 | 14637 | 65  |
| shot.014638 | ARAD-2 | 14638 | 14749 | 66  |
| shot.014750 | ARAD-2 | 14750 | 14861 | 67  |
| shot.014862 | ARAD-2 | 14862 | 14973 | 68  |
| shot.014978 | ARAD-2 | 14978 | 15088 | 72  |
| shot.015089 | ARAD-2 | 15089 | 15200 | 73  |
| shot.015201 | ARAD-2 | 15201 | 15312 | 74  |
| shot.015313 | ARAD-2 | 15313 | 15424 | 75  |
| shot.015425 | ARAD-2 | 15425 | 15536 | 76  |
| shot.015537 | ARAD-2 | 15537 | 15648 | 77  |
| shot.015649 | ARAD-2 | 15649 | 15760 | 78  |
| shot.015761 | ARAD-2 | 15761 | 15872 | 79  |
| shot.015873 | ARAD-2 | 15873 | 15984 | 80  |
| shot.015985 | ARAD-2 | 15985 | 16096 | 81  |
| shot.016097 | ARAD-2 | 16097 | 16208 | 82  |
| shot.016209 | ARAD-2 | 16209 | 16320 | 83  |
| shot.016321 | ARAD-2 | 16321 | 16432 | 84  |
| shot.016433 | ARAD-2 | 16433 | 16544 | 85  |
| shot.016545 | ARAD-2 | 16545 | 16656 | 86  |
| shot.016657 | ARAD-2 | 16657 | 16768 | 87  |
| shot.016769 | ARAD-2 | 16769 | 16880 | 88  |
| shot.016881 | ARAD-2 | 16881 | 16992 | 89  |
| shot.016993 | ARAD-2 | 16993 | 17104 | 90  |
| shot.017105 | ARAD-2 | 17105 | 17216 | 91  |
| shot.017217 | ARAD-2 | 17217 | 17328 | 92  |
| shot.017329 | ARAD-2 | 17329 | 17440 | 93  |
| shot.017441 | ARAD-2 | 17441 | 17552 | 94  |
| shot.017553 | ARAD-2 | 17553 | 17664 | 95  |
| shot.017665 | ARAD-2 | 17665 | 17776 | 96  |
| shot.017777 | ARAD-2 | 17777 | 17888 | 97  |
| shot.017889 | ARAD-2 | 17889 | 18000 | 98  |
| shot.018001 | ARAD-2 | 18001 | 18112 | 99  |
| shot.018113 | ARAD-2 | 18113 | 18224 | 100 |
| shot.018225 | ARAD-2 | 18225 | 18336 | 101 |
| shot.018337 | ARAD-2 | 18337 | 18448 | 102 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.018449 | ARAD-2 | 18449 | 18561 | 103 |
| shot.018562 | ARAD-2 | 18562 | 18673 | 104 |
| shot.018674 | ARAD-2 | 18674 | 18785 | 105 |
| shot.018786 | ARAD-2 | 18786 | 18897 | 106 |
| shot.018898 | ARAD-2 | 18898 | 19009 | 107 |
| shot.019010 | ARAD-2 | 19010 | 19121 | 108 |
| shot.019122 | ARAD-2 | 19122 | 19233 | 109 |
| shot.019234 | ARAD-2 | 19234 | 19345 | 110 |
| shot.019346 | ARAD-2 | 19346 | 19457 | 111 |
| shot.019458 | ARAD-2 | 19458 | 19569 | 112 |
| shot.019570 | ARAD-2 | 19570 | 19681 | 113 |
| shot.019682 | ARAD-2 | 19682 | 19793 | 114 |
| shot.019794 | ARAD-2 | 19794 | 19905 | 115 |
| shot.019906 | ARAD-2 | 19906 | 20017 | 116 |
| shot.020018 | ARAD-2 | 20018 | 20129 | 117 |
| shot.020130 | ARAD-2 | 20130 | 20241 | 118 |
| shot.020242 | ARAD-2 | 20242 | 20353 | 119 |
| shot.020354 | ARAD-2 | 20354 | 20465 | 120 |
| shot.020466 | ARAD-2 | 20466 | 20577 | 121 |
| shot.020578 | ARAD-2 | 20578 | 20689 | 122 |
| shot.020690 | ARAD-2 | 20690 | 20801 | 123 |
| shot.020802 | ARAD-2 | 20802 | 20913 | 124 |
| shot.020917 | ARAD-2 | 20917 | 21026 | 127 |
| shot.021027 | ARAD-2 | 21027 | 21138 | 128 |
| shot.021139 | ARAD-2 | 21139 | 21250 | 129 |
| shot.021251 | ARAD-2 | 21251 | 21362 | 130 |
| shot.021363 | ARAD-2 | 21363 | 21474 | 131 |
| shot.021475 | ARAD-2 | 21475 | 21586 | 132 |
| shot.021587 | ARAD-2 | 21587 | 21698 | 133 |
| shot.021699 | ARAD-2 | 21699 | 21810 | 134 |
| shot.021811 | ARAD-2 | 21811 | 21922 | 135 |
| shot.021923 | ARAD-2 | 21923 | 22034 | 136 |
| shot.022035 | ARAD-2 | 22035 | 22146 | 137 |
| shot.022147 | ARAD-2 | 22147 | 22258 | 138 |
| shot.022259 | ARAD-2 | 22259 | 22370 | 139 |
| shot.022371 | ARAD-2 | 22371 | 22482 | 140 |
| shot.022483 | ARAD-2 | 22483 | 22594 | 141 |
| shot.022595 | ARAD-2 | 22595 | 22706 | 142 |
| shot.022707 | ARAD-2 | 22707 | 22818 | 143 |
| shot.022819 | ARAD-2 | 22819 | 22930 | 144 |
| shot.022931 | ARAD-2 | 22931 | 23042 | 145 |
| shot.023043 | ARAD-2 | 23043 | 23154 | 146 |
| shot.023155 | ARAD-2 | 23155 | 23266 | 147 |
| shot.023267 | ARAD-2 | 23267 | 23378 | 148 |
| shot.023379 | ARAD-2 | 23379 | 23490 | 149 |
| shot.023491 | ARAD-2 | 23491 | 23602 | 150 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.023603 | ARAD-2 | 23603 | 23714 | 151 |
| shot.023715 | ARAD-2 | 23715 | 23826 | 152 |
| shot.023827 | ARAD-2 | 23827 | 23938 | 153 |
| shot.023939 | ARAD-2 | 23939 | 24050 | 154 |
| shot.024051 | ARAD-2 | 24051 | 24162 | 155 |
| shot.024163 | ARAD-2 | 24163 | 24274 | 156 |
| shot.024275 | ARAD-2 | 24275 | 24386 | 157 |
| shot.024387 | ARAD-2 | 24387 | 24498 | 158 |
| shot.024502 | ARAD-2 | 24502 | 24611 | 161 |
| shot.024612 | ARAD-2 | 24612 | 24723 | 162 |
| shot.024724 | ARAD-2 | 24724 | 24835 | 163 |
| shot.024836 | ARAD-2 | 24836 | 24947 | 164 |
| shot.024948 | ARAD-2 | 24948 | 25059 | 165 |
| shot.025060 | ARAD-2 | 25060 | 25172 | 166 |
| shot.025173 | ARAD-2 | 25173 | 25284 | 167 |
| shot.025285 | ARAD-2 | 25285 | 25396 | 168 |
| shot.025397 | ARAD-2 | 25397 | 25508 | 169 |
| shot.025509 | ARAD-2 | 25509 | 25620 | 170 |
| shot.025621 | ARAD-2 | 25621 | 25732 | 171 |
| shot.025733 | ARAD-2 | 25733 | 25844 | 172 |
| shot.025845 | ARAD-2 | 25845 | 25956 | 173 |
| shot.025957 | ARAD-2 | 25957 | 26068 | 174 |
| shot.026069 | ARAD-2 | 26069 | 26180 | 175 |
| shot.026181 | ARAD-2 | 26181 | 26292 | 176 |
| shot.026293 | ARAD-2 | 26293 | 26404 | 177 |
| shot.026405 | ARAD-2 | 26405 | 26516 | 178 |
| shot.026517 | ARAD-2 | 26517 | 26628 | 179 |
| shot.026629 | ARAD-2 | 26629 | 26740 | 180 |
| shot.026741 | ARAD-2 | 26741 | 26852 | 181 |
| shot.026853 | ARAD-2 | 26853 | 26964 | 182 |
| shot.026965 | ARAD-2 | 26965 | 27077 | 183 |
| shot.027078 | ARAD-2 | 27078 | 27189 | 184 |
| shot.027195 | ARAD-2 | 27195 | 27305 | 190 |
| shot.027306 | ARAD-2 | 27306 | 27417 | 191 |
| shot.027418 | ARAD-2 | 27418 | 27529 | 192 |
| shot.027533 | ARAD-2 | 27533 | 27642 | 195 |
| shot.027643 | ARAD-2 | 27643 | 27754 | 196 |
| shot.027755 | ARAD-2 | 27755 | 27866 | 197 |
| shot.027867 | ARAD-2 | 27867 | 27978 | 198 |
| shot.027979 | ARAD-2 | 27979 | 28090 | 199 |
| shot.028091 | ARAD-2 | 28091 | 28202 | 200 |
| shot.028203 | ARAD-2 | 28203 | 28314 | 201 |
| shot.028315 | ARAD-2 | 28315 | 28426 | 202 |
| shot.028427 | ARAD-2 | 28427 | 28538 | 203 |
| shot.028539 | ARAD-2 | 28539 | 28650 | 204 |
| shot.028651 | ARAD-2 | 28651 | 28762 | 205 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.028763 | ARAD-2 | 28763 | 28874 | 206 |
| shot.028875 | ARAD-2 | 28875 | 28986 | 207 |
| shot.028987 | ARAD-2 | 28987 | 29098 | 208 |
| shot.029099 | ARAD-2 | 29099 | 29210 | 209 |
| shot.029211 | ARAD-2 | 29211 | 29322 | 210 |
| shot.029323 | ARAD-2 | 29323 | 29434 | 211 |
| shot.029435 | ARAD-2 | 29435 | 29546 | 212 |
| shot.029547 | ARAD-2 | 29547 | 29658 | 213 |
| shot.029659 | ARAD-2 | 29659 | 29770 | 214 |
| shot.029771 | ARAD-2 | 29771 | 29882 | 215 |
| shot.029883 | ARAD-2 | 29883 | 29994 | 216 |
| shot.029995 | ARAD-2 | 29995 | 30106 | 217 |
| shot.030107 | ARAD-2 | 30107 | 30218 | 218 |
| shot.030219 | ARAD-2 | 30219 | 30330 | 219 |
| shot.030331 | ARAD-2 | 30331 | 30442 | 220 |
| shot.030443 | ARAD-2 | 30443 | 30554 | 221 |
| shot.030555 | ARAD-2 | 30555 | 30666 | 222 |
| shot.030667 | ARAD-2 | 30667 | 30778 | 223 |
| shot.030779 | ARAD-2 | 30779 | 30890 | 224 |
| shot.030891 | ARAD-2 | 30891 | 31002 | 225 |
| shot.031003 | ARAD-2 | 31003 | 31114 | 226 |
| shot.031115 | ARAD-2 | 31115 | 31226 | 227 |
| shot.031227 | ARAD-2 | 31227 | 31338 | 228 |
| shot.031339 | ARAD-2 | 31339 | 31450 | 229 |
| shot.031451 | ARAD-2 | 31451 | 31562 | 230 |
| shot.031563 | ARAD-2 | 31563 | 31674 | 231 |
| shot.031675 | ARAD-2 | 31675 | 31786 | 232 |
| shot.031787 | ARAD-2 | 31787 | 31898 | 233 |
| shot.031899 | ARAD-2 | 31899 | 32010 | 234 |
| shot.032011 | ARAD-2 | 32011 | 32122 | 235 |
| shot.032123 | ARAD-2 | 32123 | 32234 | 236 |
| shot.032235 | ARAD-2 | 32235 | 32346 | 237 |
| shot.032347 | ARAD-2 | 32347 | 32458 | 238 |
| shot.032459 | ARAD-2 | 32459 | 32570 | 239 |
| shot.032571 | ARAD-2 | 32571 | 32682 | 240 |
| shot.032683 | ARAD-2 | 32683 | 32794 | 241 |
| shot.032795 | ARAD-2 | 32795 | 32906 | 242 |
| shot.032907 | ARAD-2 | 32907 | 33018 | 243 |
| shot.033019 | ARAD-2 | 33019 | 33130 | 244 |
| shot.033131 | ARAD-2 | 33131 | 33242 | 245 |
| shot.033243 | ARAD-2 | 33243 | 33354 | 246 |
| shot.033355 | ARAD-2 | 33355 | 33466 | 247 |
| shot.033467 | ARAD-2 | 33467 | 33578 | 248 |
| shot.033579 | ARAD-2 | 33579 | 33690 | 249 |
| shot.033691 | ARAD-2 | 33691 | 33802 | 250 |
| shot.033803 | ARAD-2 | 33803 | 33914 | 251 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.033915 | ARAD-2 | 33915 | 34026 | 252 |
| shot.034027 | ARAD-2 | 34027 | 34138 | 253 |
| shot.034139 | ARAD-2 | 34139 | 34250 | 254 |
| shot.034251 | ARAD-2 | 34251 | 34362 | 255 |
| shot.034363 | ARAD-2 | 34363 | 34474 | 256 |
| shot.034478 | ARAD-2 | 34478 | 34587 | 259 |
| shot.034588 | ARAD-2 | 34588 | 34699 | 260 |
| shot.034700 | ARAD-2 | 34700 | 34811 | 261 |
| shot.034812 | ARAD-2 | 34812 | 34923 | 262 |
| shot.034924 | ARAD-2 | 34924 | 35035 | 263 |
| shot.035036 | ARAD-2 | 35036 | 35147 | 264 |
| shot.035152 | ARAD-2 | 35152 | 35262 | 268 |
| shot.035263 | ARAD-2 | 35263 | 35374 | 269 |
| shot.035375 | ARAD-2 | 35375 | 35486 | 270 |
| shot.035487 | ARAD-2 | 35487 | 35599 | 271 |
| shot.035600 | ARAD-2 | 35600 | 35711 | 272 |
| shot.035712 | ARAD-2 | 35712 | 35823 | 273 |
| shot.035824 | ARAD-2 | 35824 | 35935 | 274 |
| shot.035936 | ARAD-2 | 35936 | 36047 | 275 |
| shot.036048 | ARAD-2 | 36048 | 36159 | 276 |
| shot.036164 | ARAD-2 | 36164 | 36273 | 280 |
| shot.036274 | ARAD-2 | 36274 | 36385 | 281 |
| shot.036386 | ARAD-2 | 36386 | 36498 | 282 |
| shot.036499 | ARAD-2 | 36499 | 36610 | 283 |
| shot.036611 | ARAD-2 | 36611 | 36722 | 284 |
| shot.036726 | ARAD-2 | 36726 | 36835 | 287 |
| shot.036836 | ARAD-2 | 36836 | 36947 | 288 |
| shot.036948 | ARAD-2 | 36948 | 37059 | 289 |
| shot.037060 | ARAD-2 | 37060 | 37171 | 290 |
| shot.037176 | ARAD-2 | 37176 | 37286 | 295 |
| shot.037287 | ARAD-2 | 37287 | 37398 | 296 |
| shot.037399 | ARAD-2 | 37399 | 37510 | 297 |
| shot.037511 | ARAD-2 | 37511 | 37622 | 298 |
| shot.037623 | ARAD-2 | 37623 | 37734 | 299 |
| shot.037735 | ARAD-2 | 37735 | 37846 | 300 |
| shot.037847 | ARAD-2 | 37847 | 37958 | 301 |
| shot.037959 | ARAD-2 | 37959 | 38070 | 302 |
| shot.038071 | ARAD-2 | 38071 | 38182 | 303 |
| shot.038183 | ARAD-2 | 38183 | 38294 | 304 |
| shot.038295 | ARAD-2 | 38295 | 38406 | 305 |
| shot.038407 | ARAD-2 | 38407 | 38518 | 306 |
| shot.038523 | ARAD-2 | 38523 | 38632 | 310 |
| shot.038633 | ARAD-2 | 38633 | 38744 | 311 |
| shot.038745 | ARAD-2 | 38745 | 38856 | 312 |
| shot.038857 | ARAD-2 | 38857 | 38968 | 313 |
| shot.038969 | ARAD-2 | 38969 | 39080 | 314 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.039081 | ARAD-2 | 39081 | 39192 | 315 |
| shot.039193 | ARAD-2 | 39193 | 39304 | 316 |
| shot.039305 | ARAD-2 | 39305 | 39416 | 317 |
| shot.039417 | ARAD-2 | 39417 | 39528 | 318 |
| shot.039529 | ARAD-2 | 39529 | 39640 | 319 |
| shot.039641 | ARAD-2 | 39641 | 39752 | 32  |
| shot.039758 | ARAD-2 | 39758 | 39867 | 325 |
| shot.039868 | ARAD-2 | 39868 | 39979 | 326 |
| shot.039980 | ARAD-2 | 39980 | 40091 | 327 |
| shot.040092 | ARAD-2 | 40092 | 40203 | 328 |
| shot.040204 | ARAD-2 | 40204 | 40315 | 329 |
| shot.040316 | ARAD-2 | 40316 | 40427 | 330 |
| shot.040428 | ARAD-2 | 40428 | 40539 | 331 |
| shot.040540 | ARAD-2 | 40540 | 40651 | 332 |
| shot.040652 | ARAD-2 | 40652 | 40763 | 333 |
| shot.040764 | ARAD-2 | 40764 | 40876 | 334 |
| shot.040880 | ARAD-2 | 40880 | 40989 | 337 |
| shot.040990 | ARAD-2 | 40990 | 41101 | 338 |
| shot.041102 | ARAD-2 | 41102 | 41213 | 339 |
| shot.041214 | ARAD-2 | 41214 | 41325 | 340 |
| shot.041326 | ARAD-2 | 41326 | 41437 | 341 |
| shot.041438 | ARAD-2 | 41438 | 41549 | 342 |
| shot.041555 | ARAD-2 | 41555 | 41664 | 347 |
| shot.041665 | ARAD-2 | 41665 | 41776 | 348 |
| shot.041777 | ARAD-2 | 41777 | 41888 | 349 |
| shot.041889 | ARAD-2 | 41889 | 42000 | 350 |
| shot.042001 | ARAD-2 | 42001 | 42112 | 351 |
| shot.042113 | ARAD-2 | 42113 | 42224 | 352 |
| shot.042229 | ARAD-2 | 42229 | 42349 | 356 |
| shot.042345 | ARAD-2 | 42345 | 42454 | 361 |
| shot.042455 | ARAD-2 | 42455 | 42566 | 362 |
| shot.042567 | ARAD-2 | 42567 | 42678 | 363 |
| shot.042679 | ARAD-2 | 42679 | 42790 | 364 |
| shot.042791 | ARAD-2 | 42791 | 42902 | 365 |
| shot.042903 | ARAD-2 | 42903 | 43014 | 366 |
| shot.043015 | ARAD-2 | 43015 | 43054 | 367 |
| shot.043055 | ARAD-2 | 43055 | 43165 | 368 |
| shot.043166 | ARAD-2 | 43166 | 43277 | 369 |
| shot.043278 | ARAD-2 | 43278 | 43389 | 370 |
| shot.043390 | ARAD-2 | 43390 | 43501 | 371 |
| shot.043502 | ARAD-2 | 43502 | 43613 | 372 |
| shot.043614 | ARAD-2 | 43614 | 43725 | 373 |
| shot.043726 | ARAD-2 | 43726 | 43837 | 374 |
| shot.043838 | ARAD-2 | 43838 | 43950 | 375 |
| shot.043951 | ARAD-2 | 43951 | 44062 | 376 |
| shot.044063 | ARAD-2 | 44063 | 44174 | 377 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.044175 | ARAD-2 | 44175 | 44286 | 378 |
| shot.044292 | ARAD-2 | 44292 | 44403 | 384 |
| shot.044404 | ARAD-2 | 44404 | 44515 | 385 |
| shot.044516 | ARAD-2 | 44516 | 44627 | 386 |
| shot.044628 | ARAD-2 | 44628 | 44739 | 387 |
| shot.044740 | ARAD-2 | 44740 | 44851 | 388 |
| shot.044852 | ARAD-2 | 44852 | 44963 | 389 |
| shot.044964 | ARAD-2 | 44964 | 45075 | 390 |
| shot.045076 | ARAD-2 | 45076 | 45187 | 391 |
| shot.045188 | ARAD-2 | 45188 | 45299 | 392 |
| shot.045300 | ARAD-2 | 45300 | 45411 | 393 |
| shot.045412 | ARAD-2 | 45412 | 45523 | 394 |
| shot.045524 | ARAD-2 | 45524 | 45635 | 395 |
| shot.045636 | ARAD-2 | 45636 | 45747 | 396 |
| shot.045753 | ARAD-2 | 45753 | 45862 | 401 |
| shot.045863 | ARAD-2 | 45863 | 45974 | 402 |
| shot.045975 | ARAD-2 | 45975 | 46086 | 403 |
| shot.046087 | ARAD-2 | 46087 | 46198 | 404 |
| shot.046203 | ARAD-2 | 46203 | 46312 | 408 |
| shot.046313 | ARAD-2 | 46313 | 46424 | 409 |
| shot.046425 | ARAD-2 | 46425 | 46536 | 410 |
| shot.046537 | ARAD-2 | 46537 | 46648 | 411 |
| shot.046649 | ARAD-2 | 46649 | 46760 | 412 |
| shot.046761 | ARAD-2 | 46761 | 46872 | 413 |
| shot.046873 | ARAD-2 | 46873 | 46984 | 414 |
| shot.046990 | ARAD-2 | 46990 | 47100 | 420 |
| shot.047101 | ARAD-2 | 47101 | 47212 | 421 |
| shot.047213 | ARAD-2 | 47213 | 47324 | 422 |
| shot.047325 | ARAD-2 | 47325 | 47436 | 423 |
| shot.047437 | ARAD-2 | 47437 | 47548 | 424 |
| shot.047549 | ARAD-2 | 47549 | 47661 | 425 |
| shot.047662 | ARAD-2 | 47662 | 47773 | 426 |
| shot.047774 | ARAD-2 | 47774 | 47885 | 427 |
| shot.047886 | ARAD-2 | 47886 | 47997 | 428 |
| shot.047998 | ARAD-2 | 47998 | 48109 | 429 |
| shot.048110 | ARAD-2 | 48110 | 48221 | 430 |
| shot.048222 | ARAD-2 | 48222 | 48333 | 431 |
| shot.048334 | ARAD-2 | 48334 | 48445 | 432 |
| shot.048446 | ARAD-2 | 48446 | 48557 | 433 |
| shot.048558 | ARAD-2 | 48558 | 48669 | 434 |
| shot.048670 | ARAD-2 | 48670 | 48782 | 435 |
| shot.048783 | ARAD-2 | 48783 | 48894 | 436 |
| shot.048895 | ARAD-2 | 48895 | 49006 | 437 |
| shot.049007 | ARAD-2 | 49007 | 49118 | 438 |
| shot.049119 | ARAD-2 | 49119 | 49230 | 439 |
| shot.049231 | ARAD-2 | 49231 | 49342 | 440 |



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|-------------|--------|-------|-------|-----|
| shot.049343 | ARAD-2 | 49343 | 49454 | 441 |
| shot.049455 | ARAD-2 | 49455 | 49566 | 442 |
| shot.049567 | ARAD-2 | 49567 | 49595 | 443 |
| shot.049596 | ARAD-2 | 49596 | 49710 | 444 |
| shot.049712 | ARAD-2 | 49712 | 49821 | 449 |
| shot.049822 | ARAD-2 | 49822 | 49933 | 450 |
| shot.049934 | ARAD-2 | 49934 | 50045 | 451 |
| shot.050046 | ARAD-2 | 50046 | 50157 | 452 |
| shot.050158 | ARAD-2 | 50158 | 50269 | 453 |
| shot.050270 | ARAD-2 | 50270 | 50381 | 454 |
| shot.050382 | ARAD-2 | 50382 | 50493 | 455 |
| shot.050494 | ARAD-2 | 50494 | 50606 | 456 |
| shot.050607 | ARAD-2 | 50607 | 50719 | 457 |
| shot.050720 | ARAD-2 | 50720 | 50831 | 458 |
| shot.050832 | ARAD-2 | 50832 | 50943 | 459 |
| shot.050944 | ARAD-2 | 50944 | 51055 | 460 |
| shot.051056 | ARAD-2 | 51056 | 51167 | 461 |
| shot.051168 | ARAD-2 | 51168 | 51279 | 462 |
| shot.051280 | ARAD-2 | 51280 | 51391 | 463 |
| shot.051392 | ARAD-2 | 51392 | 51503 | 464 |
| shot.051504 | ARAD-2 | 51504 | 51615 | 465 |
| shot.051616 | ARAD-2 | 51616 | 51727 | 466 |
| shot.051728 | ARAD-2 | 51728 | 51839 | 467 |
| shot.051840 | ARAD-2 | 51840 | 51951 | 468 |
| shot.051952 | ARAD-2 | 51952 | 52063 | 469 |
| shot.052064 | ARAD-2 | 52064 | 52175 | 470 |
| shot.052176 | ARAD-2 | 52176 | 52287 | 471 |
| shot.052288 | ARAD-2 | 52288 | 52399 | 472 |
| shot.052400 | ARAD-2 | 52400 | 52511 | 473 |
| shot.052512 | ARAD-2 | 52512 | 52623 | 474 |
| shot.052624 | ARAD-2 | 52624 | 52735 | 475 |
| shot.052736 | ARAD-2 | 52736 | 52847 | 476 |
| shot.052848 | ARAD-2 | 52848 | 52959 | 477 |
| shot.052960 | ARAD-2 | 52960 | 53071 | 478 |
| shot.053075 | ARAD-2 | 53075 | 53184 | 481 |
| shot.053185 | ARAD-2 | 53185 | 53296 | 482 |
| shot.053297 | ARAD-2 | 53297 | 53408 | 483 |
| shot.053409 | ARAD-2 | 53409 | 53520 | 484 |
| shot.053521 | ARAD-2 | 53521 | 53632 | 485 |
| shot.053633 | ARAD-2 | 53633 | 53744 | 486 |
| shot.053745 | ARAD-2 | 53745 | 53856 | 487 |
| shot.053857 | ARAD-2 | 53857 | 53968 | 488 |
| shot.053969 | ARAD-2 | 53969 | 54080 | 489 |
| shot.054081 | ARAD-2 | 54081 | 54192 | 490 |
| shot.054193 | ARAD-2 | 54193 | 54304 | 491 |
| shot.054305 | ARAD-2 | 54305 | 54416 | 492 |



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|-------------|--------|-------|-------|-----|
| shot.054417 | ARAD-2 | 54417 | 54528 | 493 |
| shot.054529 | ARAD-2 | 54529 | 54640 | 494 |
| shot.054641 | ARAD-2 | 54641 | 54752 | 495 |
| shot.054753 | ARAD-2 | 54753 | 54864 | 496 |
| shot.054865 | ARAD-2 | 54865 | 54976 | 497 |
| shot.054977 | ARAD-2 | 54977 | 55088 | 498 |
| shot.055089 | ARAD-2 | 55089 | 55200 | 499 |
| shot.055201 | ARAD-2 | 55201 | 55312 | 500 |
| shot.055313 | ARAD-2 | 55313 | 55424 | 501 |
| shot.055425 | ARAD-2 | 55425 | 55537 | 502 |
| shot.055538 | ARAD-2 | 55538 | 55649 | 503 |
| shot.055650 | ARAD-2 | 55650 | 55761 | 504 |
| shot.055762 | ARAD-2 | 55762 | 55873 | 505 |
| shot.055874 | ARAD-2 | 55874 | 55985 | 506 |
| shot.055986 | ARAD-2 | 55986 | 56097 | 507 |
| shot.056098 | ARAD-2 | 56098 | 56209 | 508 |
| shot.056210 | ARAD-2 | 56210 | 56321 | 509 |
| shot.056322 | ARAD-2 | 56322 | 56433 | 510 |
| shot.056434 | ARAD-2 | 56434 | 56546 | 511 |
| shot.056547 | ARAD-2 | 56547 | 56658 | 512 |
| shot.056659 | ARAD-2 | 56659 | 56770 | 513 |
| shot.056771 | ARAD-2 | 56771 | 56882 | 514 |
| shot.056883 | ARAD-2 | 56883 | 56994 | 515 |
| shot.056995 | ARAD-2 | 56995 | 57106 | 516 |
| shot.057107 | ARAD-2 | 57107 | 57218 | 517 |
| shot.057219 | ARAD-2 | 57219 | 57330 | 518 |
| shot.057331 | ARAD-2 | 57331 | 57442 | 519 |
| shot.057443 | ARAD-2 | 57443 | 57554 | 520 |
| shot.057555 | ARAD-2 | 57555 | 57666 | 521 |
| shot.057667 | ARAD-2 | 57667 | 57778 | 522 |
| shot.057779 | ARAD-2 | 57779 | 57890 | 523 |
| shot.057891 | ARAD-2 | 57891 | 58002 | 524 |
| shot.058008 | ARAD-2 | 58008 | 58118 | 530 |
| shot.058119 | ARAD-2 | 58119 | 58230 | 531 |
| shot.058231 | ARAD-2 | 58231 | 58342 | 532 |
| shot.058343 | ARAD-2 | 58343 | 58454 | 533 |
| shot.058455 | ARAD-2 | 58455 | 58566 | 534 |
| shot.058567 | ARAD-2 | 58567 | 58678 | 535 |
| shot.058679 | ARAD-2 | 58679 | 58790 | 536 |
| shot.058791 | ARAD-2 | 58791 | 58902 | 537 |
| shot.058903 | ARAD-2 | 58903 | 59014 | 538 |
| shot.059018 | ARAD-2 | 59018 | 59127 | 541 |
| shot.059128 | ARAD-2 | 59128 | 59239 | 542 |
| shot.059240 | ARAD-2 | 59240 | 59351 | 543 |
| shot.059352 | ARAD-2 | 59352 | 59463 | 544 |
| shot.059464 | ARAD-2 | 59464 | 59575 | 545 |



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|-------------|--------|-------|-------|-----|
| shot.059576 | ARAD-2 | 59576 | 59687 | 546 |
| shot.059688 | ARAD-2 | 59688 | 59799 | 547 |
| shot.059800 | ARAD-2 | 59800 | 59914 | 548 |
| shot.059916 | ARAD-2 | 59916 | 60025 | 552 |
| shot.060026 | ARAD-2 | 60026 | 60137 | 553 |
| shot.060138 | ARAD-2 | 60138 | 60249 | 554 |
| shot.060250 | ARAD-2 | 60250 | 60362 | 555 |
| shot.060363 | ARAD-2 | 60363 | 60474 | 556 |
| shot.060479 | ARAD-2 | 60479 | 60588 | 560 |
| shot.060589 | ARAD-2 | 60589 | 60700 | 561 |
| shot.060701 | ARAD-2 | 60701 | 60809 | 562 |
| shot.060810 | ARAD-2 | 60810 | 60920 | 563 |
| shot.060921 | ARAD-2 | 60921 | 61032 | 564 |
| shot.061033 | ARAD-2 | 61033 | 61144 | 565 |
| shot.061145 | ARAD-2 | 61145 | 61256 | 566 |
| shot.061257 | ARAD-2 | 61257 | 61368 | 567 |
| shot.061369 | ARAD-2 | 61369 | 61480 | 568 |
| shot.061481 | ARAD-2 | 61481 | 61592 | 569 |
| shot.061593 | ARAD-2 | 61593 | 61704 | 570 |
| shot.061709 | ARAD-2 | 61709 | 61818 | 574 |
| shot.061819 | ARAD-2 | 61819 | 61930 | 575 |
| shot.061931 | ARAD-2 | 61931 | 62042 | 576 |
| shot.062043 | ARAD-2 | 62043 | 62154 | 577 |
| shot.062155 | ARAD-2 | 62155 | 62266 | 578 |
| shot.062267 | ARAD-2 | 62267 | 62378 | 579 |
| shot.062379 | ARAD-2 | 62379 | 62490 | 580 |
| shot.062491 | ARAD-2 | 62491 | 62603 | 581 |
| shot.062604 | ARAD-2 | 62604 | 62716 | 582 |
| shot.062717 | ARAD-2 | 62717 | 62828 | 583 |
| shot.062829 | ARAD-2 | 62829 | 62940 | 584 |
| shot.062941 | ARAD-2 | 62941 | 63052 | 585 |
| shot.063053 | ARAD-2 | 63053 | 63164 | 586 |
| shot.063169 | ARAD-2 | 63169 | 63278 | 590 |
| shot.063279 | ARAD-2 | 63279 | 63390 | 591 |
| shot.063391 | ARAD-2 | 63391 | 63502 | 592 |
| shot.063503 | ARAD-2 | 63503 | 63614 | 593 |
| shot.063615 | ARAD-2 | 63615 | 63726 | 594 |
| shot.063731 | ARAD-2 | 63731 | 63841 | 599 |
| shot.063842 | ARAD-2 | 63842 | 63953 | 600 |
| shot.063954 | ARAD-2 | 63954 | 64065 | 601 |
| shot.064066 | ARAD-2 | 64066 | 64177 | 602 |
| shot.064178 | ARAD-2 | 64178 | 64289 | 603 |
| shot.064290 | ARAD-2 | 64290 | 64401 | 604 |
| shot.064406 | ARAD-2 | 64406 | 64516 | 609 |
| shot.064517 | ARAD-2 | 64517 | 64628 | 610 |
| shot.064629 | ARAD-2 | 64629 | 64740 | 611 |



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|-------------|--------|-------|-------|-----|
| shot.064741 | ARAD-2 | 64741 | 64852 | 612 |
| shot.064853 | ARAD-2 | 64853 | 64964 | 613 |
| shot.064965 | ARAD-2 | 64965 | 65076 | 614 |
| shot.065077 | ARAD-2 | 65077 | 65188 | 615 |
| shot.065189 | ARAD-2 | 65189 | 65300 | 616 |
| shot.065301 | ARAD-2 | 65301 | 65412 | 617 |
| shot.065413 | ARAD-2 | 65413 | 65524 | 618 |
| shot.065525 | ARAD-2 | 65525 | 65636 | 619 |
| shot.065637 | ARAD-2 | 65637 | 65748 | 620 |
| shot.065749 | ARAD-2 | 65749 | 65860 | 621 |
| shot.065861 | ARAD-2 | 65861 | 65972 | 622 |
| shot.065973 | ARAD-2 | 65973 | 66084 | 623 |
| shot.066085 | ARAD-2 | 66085 | 66196 | 624 |
| shot.066197 | ARAD-2 | 66197 | 66308 | 625 |
| shot.066309 | ARAD-2 | 66309 | 66420 | 626 |
| shot.066421 | ARAD-2 | 66421 | 66532 | 627 |
| shot.066533 | ARAD-2 | 66533 | 66644 | 628 |
| shot.066645 | ARAD-2 | 66645 | 66756 | 629 |
| shot.066757 | ARAD-2 | 66757 | 66868 | 630 |
| shot.066869 | ARAD-2 | 66869 | 66980 | 631 |
| shot.066981 | ARAD-2 | 66981 | 67092 | 632 |
| shot.067093 | ARAD-2 | 67093 | 67204 | 633 |
| shot.067205 | ARAD-2 | 67205 | 67316 | 634 |
| shot.067317 | ARAD-2 | 67317 | 67428 | 635 |
| shot.067429 | ARAD-2 | 67429 | 67540 | 636 |
| shot.067541 | ARAD-2 | 67541 | 67652 | 637 |
| shot.067653 | ARAD-2 | 67653 | 67765 | 638 |
| shot.067766 | ARAD-2 | 67766 | 67877 | 639 |
| shot.067878 | ARAD-2 | 67878 | 67990 | 640 |
| shot.067991 | ARAD-2 | 67991 | 68102 | 641 |
| shot.068103 | ARAD-2 | 68103 | 68214 | 642 |
| shot.068215 | ARAD-2 | 68215 | 68326 | 643 |
| shot.068327 | ARAD-2 | 68327 | 68438 | 644 |
| shot.068439 | ARAD-2 | 68439 | 68550 | 645 |
| shot.068551 | ARAD-2 | 68551 | 68662 | 646 |
| shot.068663 | ARAD-2 | 68663 | 68774 | 647 |
| shot.068775 | ARAD-2 | 68775 | 68886 | 648 |
| shot.068887 | ARAD-2 | 68887 | 68998 | 649 |
| shot.068999 | ARAD-2 | 68999 | 69110 | 650 |
| shot.069115 | ARAD-2 | 69115 | 69225 | 654 |
| shot.069226 | ARAD-2 | 69226 | 69337 | 655 |
| shot.069338 | ARAD-2 | 69338 | 69449 | 656 |
| shot.069450 | ARAD-2 | 69450 | 69561 | 657 |
| shot.069562 | ARAD-2 | 69562 | 69673 | 658 |
| shot.069679 | ARAD-2 | 69679 | 69789 | 664 |
| shot.069790 | ARAD-2 | 69790 | 69901 | 665 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.069902 | ARAD-2 | 69902 | 70013 | 666 |
| shot.070018 | ARAD-2 | 70018 | 70127 | 669 |
| shot.070128 | ARAD-2 | 70128 | 70239 | 670 |
| shot.070245 | ARAD-2 | 70245 | 70355 | 676 |
| shot.070362 | ARAD-2 | 70362 | 70471 | 682 |
| shot.070475 | ARAD-2 | 70475 | 70584 | 685 |
| shot.070585 | ARAD-2 | 70585 | 71053 | 686 |
| shot.071054 | ARAD-3 | 71054 | 71174 | 1   |
| shot.071175 | ARAD-3 | 71175 | 71295 | 2   |
| shot.071299 | ARAD-3 | 71299 | 71417 | 5   |
| shot.071418 | ARAD-3 | 71418 | 71538 | 6   |
| shot.071542 | ARAD-3 | 71542 | 71661 | 9   |
| shot.071662 | ARAD-3 | 71662 | 71689 | 10  |
| shot.071690 | ARAD-3 | 71690 | 71806 | 11  |
| shot.071808 | ARAD-3 | 71808 | 71923 | 13  |
| shot.071924 | ARAD-3 | 71924 | 72040 | 14  |
| shot.072041 | ARAD-3 | 72041 | 72157 | 15  |
| shot.072158 | ARAD-3 | 72158 | 72274 | 16  |
| shot.072275 | ARAD-3 | 72275 | 72391 | 17  |
| shot.072392 | ARAD-3 | 72392 | 72508 | 18  |
| shot.072509 | ARAD-3 | 72509 | 72625 | 19  |
| shot.072626 | ARAD-3 | 72626 | 72743 | 20  |
| shot.072744 | ARAD-3 | 72744 | 72860 | 21  |
| shot.072861 | ARAD-3 | 72861 | 72977 | 22  |
| shot.072978 | ARAD-3 | 72978 | 73094 | 23  |
| shot.073095 | ARAD-3 | 73095 | 73211 | 24  |
| shot.073212 | ARAD-3 | 73212 | 73328 | 25  |
| shot.073329 | ARAD-3 | 73329 | 73445 | 26  |
| shot.073446 | ARAD-3 | 73446 | 73562 | 27  |
| shot.073563 | ARAD-3 | 73563 | 73679 | 28  |
| shot.073680 | ARAD-3 | 73680 | 73796 | 29  |
| shot.073797 | ARAD-3 | 73797 | 73913 | 30  |
| shot.073914 | ARAD-3 | 73914 | 74030 | 31  |
| shot.074031 | ARAD-3 | 74031 | 74147 | 32  |
| shot.074148 | ARAD-3 | 74148 | 74264 | 33  |
| shot.074265 | ARAD-3 | 74265 | 74381 | 34  |
| shot.074382 | ARAD-3 | 74382 | 74498 | 35  |
| shot.074499 | ARAD-3 | 74499 | 74615 | 36  |
| shot.074616 | ARAD-3 | 74616 | 74732 | 37  |
| shot.074733 | ARAD-3 | 74733 | 74849 | 38  |
| shot.074850 | ARAD-3 | 74850 | 74966 | 39  |
| shot.074967 | ARAD-3 | 74967 | 75083 | 40  |
| shot.075084 | ARAD-3 | 75084 | 75200 | 41  |
| shot.075201 | ARAD-3 | 75201 | 75318 | 42  |
| shot.075319 | ARAD-3 | 75319 | 75435 | 43  |
| shot.075436 | ARAD-3 | 75436 | 75552 | 44  |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.075553 | ARAD-3 | 75553 | 75669 | 45  |
| shot.075670 | ARAD-3 | 75670 | 75786 | 46  |
| shot.075787 | ARAD-3 | 75787 | 75903 | 47  |
| shot.075907 | ARAD-3 | 75907 | 76021 | 50  |
| shot.076022 | ARAD-3 | 76022 | 76138 | 51  |
| shot.076139 | ARAD-3 | 76139 | 76255 | 52  |
| shot.076256 | ARAD-3 | 76256 | 76373 | 53  |
| shot.076377 | ARAD-3 | 76377 | 76495 | 57  |
| shot.076497 | ARAD-3 | 76497 | 76611 | 61  |
| shot.076612 | ARAD-3 | 76612 | 76728 | 62  |
| shot.076729 | ARAD-3 | 76729 | 76845 | 63  |
| shot.076846 | ARAD-3 | 76846 | 76963 | 64  |
| shot.076964 | ARAD-3 | 76964 | 77080 | 65  |
| shot.077081 | ARAD-3 | 77081 | 77198 | 66  |
| shot.077199 | ARAD-3 | 77199 | 77315 | 67  |
| shot.077316 | ARAD-3 | 77316 | 77432 | 68  |
| shot.077433 | ARAD-3 | 77433 | 77549 | 69  |
| shot.077550 | ARAD-3 | 77550 | 77666 | 70  |
| shot.077667 | ARAD-3 | 77667 | 77783 | 71  |
| shot.077784 | ARAD-3 | 77784 | 77900 | 72  |
| shot.077901 | ARAD-3 | 77901 | 78017 | 73  |
| shot.078018 | ARAD-3 | 78018 | 78134 | 74  |
| shot.078135 | ARAD-3 | 78135 | 78251 | 75  |
| shot.078252 | ARAD-3 | 78252 | 78368 | 76  |
| shot.078369 | ARAD-3 | 78369 | 78485 | 77  |
| shot.078486 | ARAD-3 | 78486 | 78602 | 78  |
| shot.078603 | ARAD-3 | 78603 | 78719 | 79  |
| shot.078720 | ARAD-3 | 78720 | 78836 | 80  |
| shot.078837 | ARAD-3 | 78837 | 78953 | 81  |
| shot.078954 | ARAD-3 | 78954 | 79070 | 82  |
| shot.079071 | ARAD-3 | 79071 | 79187 | 83  |
| shot.079188 | ARAD-3 | 79188 | 79304 | 84  |
| shot.079305 | ARAD-3 | 79305 | 79421 | 85  |
| shot.079422 | ARAD-3 | 79422 | 79538 | 86  |
| shot.079539 | ARAD-3 | 79539 | 79655 | 87  |
| shot.079656 | ARAD-3 | 79656 | 79772 | 88  |
| shot.079773 | ARAD-3 | 79773 | 79889 | 89  |
| shot.079890 | ARAD-3 | 79890 | 80006 | 90  |
| shot.080007 | ARAD-3 | 80007 | 80123 | 91  |
| shot.080128 | ARAD-3 | 80128 | 80242 | 95  |
| shot.080247 | ARAD-3 | 80247 | 80362 | 99  |
| shot.080363 | ARAD-3 | 80363 | 80479 | 100 |
| shot.080480 | ARAD-3 | 80480 | 80596 | 101 |
| shot.080597 | ARAD-3 | 80597 | 80714 | 102 |
| shot.080715 | ARAD-3 | 80715 | 80831 | 103 |
| shot.080832 | ARAD-3 | 80832 | 80948 | 104 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.080949 | ARAD-3 | 80949 | 81065 | 105 |
| shot.081066 | ARAD-3 | 81066 | 81182 | 106 |
| shot.081183 | ARAD-3 | 81183 | 81299 | 107 |
| shot.081300 | ARAD-3 | 81300 | 81416 | 108 |
| shot.081417 | ARAD-3 | 81417 | 81533 | 109 |
| shot.081534 | ARAD-3 | 81534 | 81650 | 110 |
| shot.081651 | ARAD-3 | 81651 | 81767 | 111 |
| shot.081768 | ARAD-3 | 81768 | 81884 | 112 |
| shot.081885 | ARAD-3 | 81885 | 82001 | 113 |
| shot.082005 | ARAD-3 | 82005 | 82119 | 116 |
| shot.082120 | ARAD-3 | 82120 | 82236 | 117 |
| shot.082237 | ARAD-3 | 82237 | 82353 | 118 |
| shot.082354 | ARAD-3 | 82354 | 82470 | 119 |
| shot.082471 | ARAD-3 | 82471 | 82587 | 120 |
| shot.082588 | ARAD-3 | 82588 | 82704 | 121 |
| shot.082705 | ARAD-3 | 82705 | 82821 | 122 |
| shot.082822 | ARAD-3 | 82822 | 82938 | 123 |
| shot.082939 | ARAD-3 | 82939 | 83055 | 124 |
| shot.083056 | ARAD-3 | 83056 | 83172 | 125 |
| shot.083176 | ARAD-3 | 83176 | 83290 | 128 |
| shot.083291 | ARAD-3 | 83291 | 83407 | 129 |
| shot.083408 | ARAD-3 | 83408 | 83524 | 130 |
| shot.083525 | ARAD-3 | 83525 | 83641 | 131 |
| shot.083642 | ARAD-3 | 83642 | 83758 | 132 |
| shot.083759 | ARAD-3 | 83759 | 83875 | 133 |
| shot.083881 | ARAD-3 | 83881 | 83996 | 139 |
| shot.083997 | ARAD-3 | 83997 | 84113 | 140 |
| shot.084114 | ARAD-3 | 84114 | 84230 | 141 |
| shot.084231 | ARAD-3 | 84231 | 84347 | 142 |
| shot.084348 | ARAD-3 | 84348 | 84464 | 143 |
| shot.084465 | ARAD-3 | 84465 | 84581 | 144 |
| shot.084582 | ARAD-3 | 84582 | 84698 | 145 |
| shot.084699 | ARAD-3 | 84699 | 84815 | 146 |
| shot.084816 | ARAD-3 | 84816 | 84932 | 147 |
| shot.084937 | ARAD-3 | 84937 | 85051 | 151 |
| shot.085052 | ARAD-3 | 85052 | 85168 | 152 |
| shot.085169 | ARAD-3 | 85169 | 85285 | 153 |
| shot.085286 | ARAD-3 | 85286 | 85402 | 154 |
| shot.085403 | ARAD-3 | 85403 | 85519 | 155 |
| shot.085523 | ARAD-3 | 85523 | 85637 | 158 |
| shot.085638 | ARAD-3 | 85638 | 85754 | 159 |
| shot.085755 | ARAD-3 | 85755 | 85871 | 160 |
| shot.085872 | ARAD-3 | 85872 | 85988 | 161 |
| shot.085989 | ARAD-3 | 85989 | 86105 | 162 |
| shot.086106 | ARAD-3 | 86106 | 86222 | 163 |
| shot.086223 | ARAD-3 | 86223 | 86339 | 164 |



|             |        |       |       |     |
|-------------|--------|-------|-------|-----|
| shot.086340 | ARAD-3 | 86340 | 86456 | 165 |
| shot.086457 | ARAD-3 | 86457 | 86573 | 166 |
| shot.086574 | ARAD-3 | 86574 | 86690 | 167 |
| shot.086691 | ARAD-3 | 86691 | 86807 | 168 |
| shot.086808 | ARAD-3 | 86808 | 86924 | 169 |
| shot.086925 | ARAD-3 | 86925 | 87041 | 170 |
| shot.087042 | ARAD-3 | 87042 | 87158 | 171 |
| shot.087159 | ARAD-3 | 87159 | 87275 | 172 |
| shot.087276 | ARAD-3 | 87276 | 87392 | 173 |
| shot.087393 | ARAD-3 | 87393 | 87509 | 174 |
| shot.087510 | ARAD-3 | 87510 | 87626 | 175 |
| shot.087627 | ARAD-3 | 87627 | 87743 | 176 |
| shot.087744 | ARAD-3 | 87744 | 87860 | 177 |
| shot.087861 | ARAD-3 | 87861 | 87977 | 178 |
| shot.087978 | ARAD-3 | 87978 | 88094 | 179 |
| shot.088102 | ARAD-3 | 88102 | 88217 | 184 |
| shot.088218 | ARAD-3 | 88218 | 88334 | 185 |
| shot.088335 | ARAD-3 | 88335 | 88451 | 186 |
| shot.088452 | ARAD-3 | 88452 | 88568 | 187 |
| shot.088569 | ARAD-3 | 88569 | 88685 | 188 |
| shot.088686 | ARAD-3 | 88686 | 88802 | 189 |
| shot.088803 | ARAD-3 | 88803 | 88919 | 190 |
| shot.088920 | ARAD-3 | 88920 | 89036 | 191 |
| shot.089037 | ARAD-3 | 89037 | 89153 | 192 |
| shot.089154 | ARAD-3 | 89154 | 89270 | 193 |
| shot.089271 | ARAD-3 | 89271 | 89387 | 194 |
| shot.089388 | ARAD-3 | 89388 | 89504 | 195 |
| shot.089505 | ARAD-3 | 89505 | 89621 | 196 |
| shot.089622 | ARAD-3 | 89622 | 89738 | 197 |
| shot.089739 | ARAD-3 | 89739 | 89855 | 198 |
| shot.089856 | ARAD-3 | 89856 | 89972 | 199 |
| shot.089973 | ARAD-3 | 89973 | 90089 | 200 |
| shot.090090 | ARAD-3 | 90090 | 90206 | 201 |
| shot.090207 | ARAD-3 | 90207 | 90323 | 202 |
| shot.090324 | ARAD-3 | 90324 | 90440 | 203 |
| shot.090441 | ARAD-3 | 90441 | 90558 | 204 |
| shot.090559 | ARAD-3 | 90559 | 90675 | 205 |
| shot.090676 | ARAD-3 | 90676 | 90792 | 206 |
| shot.090793 | ARAD-3 | 90793 | 90909 | 207 |
| shot.090910 | ARAD-3 | 90910 | 91026 | 208 |
| shot.091027 | ARAD-3 | 91027 | 91143 | 209 |
| shot.091144 | ARAD-3 | 91144 | 91260 | 210 |
| shot.091261 | ARAD-3 | 91261 | 91377 | 211 |
| shot.091378 | ARAD-3 | 91378 | 91494 | 212 |
| shot.091495 | ARAD-3 | 91495 | 91611 | 213 |
| shot.091612 | ARAD-3 | 91612 | 91728 | 214 |



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|-------------|--------|-------|-------|-----|
| shot.091729 | ARAD-3 | 91729 | 91845 | 215 |
| shot.091846 | ARAD-3 | 91846 | 91962 | 216 |
| shot.091963 | ARAD-3 | 91963 | 92079 | 217 |
| shot.092080 | ARAD-3 | 92080 | 92196 | 218 |
| shot.092197 | ARAD-3 | 92197 | 92313 | 219 |
| shot.092314 | ARAD-3 | 92314 | 92430 | 220 |
| shot.092431 | ARAD-3 | 92431 | 92547 | 221 |
| shot.092548 | ARAD-3 | 92548 | 92664 | 222 |
| shot.092665 | ARAD-3 | 92665 | 92781 | 223 |
| shot.092782 | ARAD-3 | 92782 | 92898 | 224 |
| shot.092899 | ARAD-3 | 92899 | 93015 | 225 |
| shot.093016 | ARAD-3 | 93016 | 93134 | 226 |
| shot.093135 | ARAD-3 | 93135 | 93251 | 227 |
| shot.093256 | ARAD-3 | 93256 | 93371 | 231 |
| shot.093372 | ARAD-3 | 93372 | 93488 | 232 |
| shot.093489 | ARAD-3 | 93489 | 93605 | 233 |
| shot.093612 | ARAD-3 | 93612 | 93726 | 237 |
| shot.093727 | ARAD-3 | 93727 | 93843 | 238 |
| shot.093844 | ARAD-3 | 93844 | 93960 | 239 |
| shot.093961 | ARAD-3 | 93961 | 94077 | 240 |
| shot.094078 | ARAD-3 | 94078 | 94194 | 241 |
| shot.094195 | ARAD-3 | 94195 | 94217 | 242 |
| shot.094218 | ARAD-3 | 94218 | 94333 | 243 |
| shot.094334 | ARAD-3 | 94334 | 94450 | 244 |
| shot.094451 | ARAD-3 | 94451 | 94567 | 245 |
| shot.094568 | ARAD-3 | 94568 | 94684 | 246 |
| shot.094685 | ARAD-3 | 94685 | 94801 | 247 |
| shot.094802 | ARAD-3 | 94802 | 94918 | 248 |
| shot.094919 | ARAD-3 | 94919 | 95035 | 249 |
| shot.095036 | ARAD-3 | 95036 | 95152 | 250 |
| shot.095153 | ARAD-3 | 95153 | 95269 | 251 |
| shot.095270 | ARAD-3 | 95270 | 95386 | 252 |
| shot.095387 | ARAD-3 | 95387 | 95503 | 253 |
| shot.095504 | ARAD-3 | 95504 | 95620 | 254 |
| shot.095621 | ARAD-3 | 95621 | 95737 | 255 |
| shot.095738 | ARAD-3 | 95738 | 95854 | 256 |
| shot.095855 | ARAD-3 | 95855 | 95971 | 257 |
| shot.095972 | ARAD-3 | 95972 | 96088 | 258 |
| shot.096089 | ARAD-3 | 96089 | 96205 | 259 |
| shot.096206 | ARAD-3 | 96206 | 96322 | 260 |
| shot.096323 | ARAD-3 | 96323 | 96439 | 261 |
| shot.096440 | ARAD-3 | 96440 | 96556 | 262 |
| shot.096557 | ARAD-3 | 96557 | 96673 | 263 |
| shot.096678 | ARAD-3 | 96678 | 96793 | 267 |
| shot.096794 | ARAD-3 | 96794 | 96910 | 268 |
| shot.096911 | ARAD-3 | 96911 | 97027 | 269 |



|             |        |        |        |     |
|-------------|--------|--------|--------|-----|
| shot.097028 | ARAD-3 | 97028  | 97144  | 270 |
| shot.097145 | ARAD-3 | 97145  | 97262  | 271 |
| shot.097268 | ARAD-3 | 97268  | 97382  | 275 |
| shot.097383 | ARAD-3 | 97383  | 97499  | 276 |
| shot.097500 | ARAD-3 | 97500  | 97616  | 277 |
| shot.097621 | ARAD-3 | 97621  | 97736  | 281 |
| shot.097737 | ARAD-3 | 97737  | 97853  | 282 |
| shot.097854 | ARAD-3 | 97854  | 97970  | 283 |
| shot.097976 | ARAD-3 | 97976  | 98091  | 289 |
| shot.098092 | ARAD-3 | 98092  | 98208  | 290 |
| shot.098209 | ARAD-3 | 98209  | 98325  | 291 |
| shot.098326 | ARAD-3 | 98326  | 98442  | 292 |
| shot.098443 | ARAD-3 | 98443  | 98559  | 293 |
| shot.098560 | ARAD-3 | 98560  | 98676  | 294 |
| shot.098677 | ARAD-3 | 98677  | 98793  | 295 |
| shot.098794 | ARAD-3 | 98794  | 98911  | 296 |
| shot.098912 | ARAD-3 | 98912  | 99028  | 297 |
| shot.099029 | ARAD-3 | 99029  | 99145  | 298 |
| shot.099146 | ARAD-3 | 99146  | 99262  | 299 |
| shot.099263 | ARAD-3 | 99263  | 99379  | 300 |
| shot.099380 | ARAD-3 | 99380  | 99496  | 301 |
| shot.099497 | ARAD-3 | 99497  | 99613  | 302 |
| shot.099614 | ARAD-3 | 99614  | 99730  | 303 |
| shot.099736 | ARAD-3 | 99736  | 99850  | 307 |
| shot.099851 | ARAD-3 | 99851  | 99967  | 308 |
| shot.099968 | ARAD-3 | 99968  | 100084 | 309 |
| shot.100085 | ARAD-3 | 100085 | 100201 | 310 |
| shot.100202 | ARAD-3 | 100202 | 100318 | 311 |
| shot.100319 | ARAD-3 | 100319 | 100355 | 312 |
| shot.100356 | ARAD-3 | 100356 | 100471 | 313 |
| shot.100472 | ARAD-3 | 100472 | 100588 | 314 |
| shot.100589 | ARAD-3 | 100589 | 100705 | 315 |
| shot.100706 | ARAD-3 | 100706 | 100822 | 316 |
| shot.100823 | ARAD-3 | 100823 | 100939 | 317 |
| shot.100940 | ARAD-3 | 100940 | 101056 | 318 |
| shot.101057 | ARAD-3 | 101057 | 101173 | 319 |
| shot.101174 | ARAD-3 | 101174 | 101290 | 320 |
| shot.101291 | ARAD-3 | 101291 | 101407 | 321 |
| shot.101408 | ARAD-3 | 101408 | 101524 | 322 |
| shot.101525 | ARAD-3 | 101525 | 101641 | 323 |
| shot.101642 | ARAD-3 | 101642 | 101759 | 324 |
| shot.101760 | ARAD-3 | 101760 | 101876 | 325 |
| shot.101877 | ARAD-3 | 101877 | 101993 | 326 |
| shot.101994 | ARAD-3 | 101994 | 102110 | 327 |
| shot.102111 | ARAD-3 | 102111 | 102227 | 328 |
| shot.102228 | ARAD-3 | 102228 | 102344 | 329 |



|             |        |        |        |     |
|-------------|--------|--------|--------|-----|
| shot.102345 | ARAD-3 | 102345 | 102461 | 330 |
| shot.102462 | ARAD-3 | 102462 | 102578 | 331 |
| shot.102579 | ARAD-3 | 102579 | 102695 | 332 |
| shot.102696 | ARAD-3 | 102696 | 102812 | 333 |
| shot.102813 | ARAD-3 | 102813 | 102929 | 334 |
| shot.102930 | ARAD-3 | 102930 | 103046 | 335 |
| shot.103047 | ARAD-3 | 103047 | 103163 | 336 |
| shot.103164 | ARAD-3 | 103164 | 103280 | 337 |
| shot.103281 | ARAD-3 | 103281 | 103397 | 338 |
| shot.103398 | ARAD-3 | 103398 | 103514 | 339 |
| shot.103515 | ARAD-3 | 103515 | 103631 | 340 |
| shot.103632 | ARAD-3 | 103632 | 103748 | 341 |
| shot.103749 | ARAD-3 | 103749 | 103865 | 342 |
| shot.103866 | ARAD-3 | 103866 | 103982 | 343 |
| shot.103986 | ARAD-3 | 103986 | 104100 | 346 |
| shot.104101 | ARAD-3 | 104101 | 104217 | 347 |
| shot.104218 | ARAD-3 | 104218 | 104334 | 348 |
| shot.104335 | ARAD-3 | 104335 | 104451 | 349 |
| shot.104452 | ARAD-3 | 104452 | 104568 | 350 |
| shot.104569 | ARAD-3 | 104569 | 104685 | 351 |
| shot.104689 | ARAD-3 | 104689 | 104805 | 355 |
| shot.104806 | ARAD-3 | 104806 | 104922 | 356 |
| shot.104923 | ARAD-3 | 104923 | 105039 | 357 |
| shot.105044 | ARAD-3 | 105044 | 105158 | 361 |
| shot.105159 | ARAD-3 | 105159 | 105275 | 362 |
| shot.105276 | ARAD-3 | 105276 | 105392 | 363 |
| shot.105395 | ARAD-3 | 105395 | 105510 | 366 |
| shot.105511 | ARAD-3 | 105511 | 105627 | 367 |
| shot.105632 | ARAD-3 | 105632 | 105746 | 371 |
| shot.105747 | ARAD-3 | 105747 | 105863 | 372 |
| shot.105864 | ARAD-3 | 105864 | 105980 | 373 |
| shot.105981 | ARAD-3 | 105981 | 106097 | 374 |
| shot.106098 | ARAD-3 | 106098 | 106214 | 375 |
| shot.106215 | ARAD-3 | 106215 | 106331 | 376 |
| shot.106332 | ARAD-3 | 106332 | 106448 | 377 |
| shot.106449 | ARAD-3 | 106449 | 106565 | 378 |
| shot.106566 | ARAD-3 | 106566 | 106682 | 379 |
| shot.106689 | ARAD-3 | 106689 | 106804 | 385 |
| shot.106805 | ARAD-3 | 106805 | 106922 | 386 |
| shot.106923 | ARAD-3 | 106923 | 107039 | 387 |
| shot.107040 | ARAD-3 | 107040 | 107156 | 388 |
| shot.107157 | ARAD-3 | 107157 | 107273 | 389 |
| shot.107274 | ARAD-3 | 107274 | 107390 | 390 |
| shot.107391 | ARAD-3 | 107391 | 107508 | 391 |
| shot.107509 | ARAD-3 | 107509 | 107625 | 392 |
| shot.107626 | ARAD-3 | 107626 | 107742 | 393 |



|             |        |        |        |     |
|-------------|--------|--------|--------|-----|
| shot.107743 | ARAD-3 | 107743 | 107859 | 394 |
| shot.107860 | ARAD-3 | 107860 | 107976 | 395 |
| shot.107977 | ARAD-3 | 107977 | 108093 | 396 |
| shot.108094 | ARAD-3 | 108094 | 108210 | 397 |
| shot.108211 | ARAD-3 | 108211 | 108327 | 398 |
| shot.108328 | ARAD-3 | 108328 | 108444 | 399 |
| shot.108445 | ARAD-3 | 108445 | 108561 | 400 |
| shot.108562 | ARAD-3 | 108562 | 108678 | 401 |
| shot.108679 | ARAD-3 | 108679 | 108795 | 402 |
| shot.108796 | ARAD-3 | 108796 | 108912 | 403 |
| shot.108913 | ARAD-3 | 108913 | 109029 | 404 |
| shot.109030 | ARAD-3 | 109030 | 109146 | 405 |
| shot.109147 | ARAD-3 | 109147 | 109263 | 406 |
| shot.109264 | ARAD-3 | 109264 | 109380 | 407 |
| shot.109381 | ARAD-3 | 109381 | 109497 | 408 |
| shot.109498 | ARAD-3 | 109498 | 109614 | 409 |
| shot.109615 | ARAD-3 | 109615 | 109731 | 410 |
| shot.109732 | ARAD-3 | 109732 | 109848 | 411 |
| shot.109849 | ARAD-3 | 109849 | 109965 | 412 |
| shot.109966 | ARAD-3 | 109966 | 110082 | 413 |
| shot.110083 | ARAD-3 | 110083 | 110199 | 414 |
| shot.110200 | ARAD-3 | 110200 | 110316 | 415 |
| shot.110317 | ARAD-3 | 110317 | 110433 | 416 |
| shot.110434 | ARAD-3 | 110434 | 110550 | 417 |
| shot.110551 | ARAD-3 | 110551 | 110667 | 418 |
| shot.110668 | ARAD-3 | 110668 | 110784 | 419 |
| shot.110788 | ARAD-3 | 110788 | 110903 | 422 |
| shot.110904 | ARAD-3 | 110904 | 111020 | 423 |
| shot.111021 | ARAD-3 | 111021 | 111137 | 424 |
| shot.111138 | ARAD-3 | 111138 | 111254 | 425 |
| shot.111255 | ARAD-3 | 111255 | 111371 | 426 |
| shot.111372 | ARAD-3 | 111372 | 111488 | 427 |
| shot.111494 | ARAD-3 | 111494 | 111608 | 432 |
| shot.111609 | ARAD-3 | 111609 | 111725 | 433 |
| shot.111726 | ARAD-3 | 111726 | 111842 | 434 |
| shot.111843 | ARAD-3 | 111843 | 111959 | 435 |
| shot.111960 | ARAD-3 | 111960 | 112076 | 436 |
| shot.112077 | ARAD-3 | 112077 | 112194 | 437 |
| shot.112198 | ARAD-3 | 112198 | 112312 | 440 |
| shot.112313 | ARAD-3 | 112313 | 112429 | 441 |
| shot.112430 | ARAD-3 | 112430 | 112546 | 442 |
| shot.112547 | ARAD-3 | 112547 | 112663 | 443 |
| shot.112667 | ARAD-3 | 112667 | 112781 | 446 |
| shot.112782 | ARAD-3 | 112782 | 112898 | 447 |
| shot.112899 | ARAD-3 | 112899 | 113015 | 448 |
| shot.113016 | ARAD-3 | 113016 | 113132 | 449 |



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|-------------|--------|--------|--------|-----|
| shot.113133 | ARAD-3 | 113133 | 113249 | 450 |
| shot.113250 | ARAD-3 | 113250 | 113366 | 451 |
| shot.113371 | ARAD-3 | 113371 | 113486 | 455 |
| shot.113487 | ARAD-3 | 113487 | 113603 | 456 |
| shot.113604 | ARAD-3 | 113604 | 113720 | 457 |
| shot.113721 | ARAD-3 | 113721 | 113837 | 458 |
| shot.113838 | ARAD-3 | 113838 | 113954 | 459 |
| shot.113955 | ARAD-3 | 113955 | 114071 | 460 |
| shot.114072 | ARAD-3 | 114072 | 114188 | 461 |
| shot.114189 | ARAD-3 | 114189 | 114305 | 462 |
| shot.114306 | ARAD-3 | 114306 | 114422 | 463 |
| shot.114423 | ARAD-3 | 114423 | 114539 | 464 |
| shot.114540 | ARAD-3 | 114540 | 114656 | 465 |
| shot.114657 | ARAD-3 | 114657 | 114773 | 466 |
| shot.114774 | ARAD-3 | 114774 | 114890 | 467 |
| shot.114896 | ARAD-3 | 114896 | 115011 | 473 |
| shot.115012 | ARAD-3 | 115012 | 115128 | 474 |
| shot.115129 | ARAD-3 | 115129 | 115245 | 475 |
| shot.115250 | ARAD-3 | 115250 | 115402 | 479 |
| shot.115403 | ARAD-3 | 115403 | 115518 | 480 |
| shot.115519 | ARAD-3 | 115519 | 115635 | 481 |
| shot.115639 | ARAD-3 | 115639 | 115754 | 484 |
| shot.115755 | ARAD-3 | 115755 | 115872 | 485 |
| shot.115873 | ARAD-3 | 115873 | 116026 | 486 |
| shot.116027 | ARAD-4 | 116027 | 116143 | 1   |
| shot.116144 | ARAD-4 | 116144 | 116260 | 2   |
| shot.116261 | ARAD-4 | 116261 | 116377 | 3   |
| shot.116378 | ARAD-4 | 116378 | 116494 | 4   |
| shot.116495 | ARAD-4 | 116495 | 116611 | 5   |
| shot.116612 | ARAD-4 | 116612 | 116728 | 6   |
| shot.116729 | ARAD-4 | 116729 | 116845 | 7   |
| shot.116846 | ARAD-4 | 116846 | 116962 | 8   |
| shot.116969 | ARAD-4 | 116969 | 117084 | 14  |
| shot.117085 | ARAD-4 | 117085 | 117201 | 15  |
| shot.117202 | ARAD-4 | 117202 | 117318 | 16  |
| shot.117323 | ARAD-4 | 117323 | 117437 | 20  |
| shot.117438 | ARAD-4 | 117438 | 117554 | 21  |
| shot.117555 | ARAD-4 | 117555 | 117671 | 22  |
| shot.117672 | ARAD-4 | 117672 | 117788 | 23  |
| shot.117789 | ARAD-4 | 117789 | 117905 | 24  |
| shot.117906 | ARAD-4 | 117906 | 118022 | 25  |
| shot.118023 | ARAD-4 | 118023 | 118139 | 26  |
| shot.118140 | ARAD-4 | 118140 | 118256 | 27  |
| shot.118257 | ARAD-4 | 118257 | 118373 | 28  |
| shot.118374 | ARAD-4 | 118374 | 118490 | 29  |
| shot.118491 | ARAD-4 | 118491 | 118607 | 30  |



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| shot.118612 | ARAD-4 | 118612 | 118727 | 34 |
| shot.118728 | ARAD-4 | 118728 | 118844 | 35 |
| shot.118845 | ARAD-4 | 118845 | 118961 | 36 |
| shot.118962 | ARAD-4 | 118962 | 119078 | 37 |
| shot.119079 | ARAD-4 | 119079 | 119195 | 38 |
| shot.119196 | ARAD-4 | 119196 | 119312 | 39 |
| shot.119313 | ARAD-4 | 119313 | 119429 | 40 |
| shot.119430 | ARAD-4 | 119430 | 119546 | 41 |
| shot.119547 | ARAD-4 | 119547 | 119663 | 42 |
| shot.119664 | ARAD-4 | 119664 | 119780 | 43 |
| shot.119781 | ARAD-4 | 119781 | 119897 | 44 |
| shot.119898 | ARAD-4 | 119898 | 120014 | 45 |
| shot.120015 | ARAD-4 | 120015 | 120131 | 46 |
| shot.120132 | ARAD-4 | 120132 | 120248 | 47 |
| shot.120249 | ARAD-4 | 120249 | 120365 | 48 |
| shot.120366 | ARAD-4 | 120366 | 120482 | 49 |
| shot.120483 | ARAD-4 | 120483 | 120599 | 50 |
| shot.120600 | ARAD-4 | 120600 | 120716 | 51 |
| shot.120717 | ARAD-4 | 120717 | 120833 | 52 |
| shot.120834 | ARAD-4 | 120834 | 120950 | 53 |
| shot.120951 | ARAD-4 | 120951 | 121067 | 54 |
| shot.121068 | ARAD-4 | 121068 | 121184 | 55 |
| shot.121185 | ARAD-4 | 121185 | 121301 | 56 |
| shot.121302 | ARAD-4 | 121302 | 121418 | 57 |
| shot.121419 | ARAD-4 | 121419 | 121535 | 58 |
| shot.121536 | ARAD-4 | 121536 | 121652 | 59 |
| shot.121653 | ARAD-4 | 121653 | 121769 | 60 |
| shot.121770 | ARAD-4 | 121770 | 121886 | 61 |
| shot.121887 | ARAD-4 | 121887 | 122003 | 62 |
| shot.122004 | ARAD-4 | 122004 | 122120 | 63 |
| shot.122121 | ARAD-4 | 122121 | 122237 | 64 |
| shot.122238 | ARAD-4 | 122238 | 122354 | 65 |
| shot.122355 | ARAD-4 | 122355 | 122471 | 66 |
| shot.122472 | ARAD-4 | 122472 | 122588 | 67 |
| shot.122589 | ARAD-4 | 122589 | 122706 | 68 |
| shot.122707 | ARAD-4 | 122707 | 122823 | 69 |
| shot.122824 | ARAD-4 | 122824 | 122940 | 70 |
| shot.122941 | ARAD-4 | 122941 | 123057 | 71 |
| shot.123058 | ARAD-4 | 123058 | 123174 | 72 |
| shot.123175 | ARAD-4 | 123175 | 123292 | 73 |
| shot.123293 | ARAD-4 | 123293 | 123409 | 74 |
| shot.123410 | ARAD-4 | 123410 | 123526 | 75 |
| shot.123527 | ARAD-4 | 123527 | 123643 | 76 |
| shot.123644 | ARAD-4 | 123644 | 123760 | 77 |
| shot.123761 | ARAD-4 | 123761 | 123877 | 78 |
| shot.123878 | ARAD-4 | 123878 | 123994 | 79 |



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|-------------|--------|--------|--------|-----|
| shot.123995 | ARAD-4 | 123995 | 121111 | 80  |
| shot.124115 | ARAD-4 | 124115 | 124229 | 82  |
| shot.124230 | ARAD-4 | 124230 | 124346 | 83  |
| shot.124347 | ARAD-4 | 124347 | 124463 | 84  |
| shot.124464 | ARAD-4 | 124464 | 124580 | 85  |
| shot.124581 | ARAD-4 | 124581 | 124697 | 86  |
| shot.124698 | ARAD-4 | 124698 | 124814 | 87  |
| shot.124815 | ARAD-4 | 124815 | 124931 | 88  |
| shot.124937 | ARAD-4 | 124937 | 125052 | 94  |
| shot.125057 | ARAD-4 | 125057 | 125172 | 98  |
| shot.125173 | ARAD-4 | 125173 | 125289 | 99  |
| shot.125290 | ARAD-4 | 125290 | 125406 | 100 |
| shot.125407 | ARAD-4 | 125407 | 125523 | 101 |
| shot.125524 | ARAD-4 | 125524 | 125640 | 102 |
| shot.125641 | ARAD-4 | 125641 | 125757 | 103 |
| shot.125758 | ARAD-4 | 125758 | 125874 | 104 |
| shot.125875 | ARAD-4 | 125875 | 125991 | 105 |
| shot.125992 | ARAD-4 | 125992 | 126108 | 106 |
| shot.126109 | ARAD-4 | 126109 | 126225 | 107 |
| shot.126226 | ARAD-4 | 126226 | 126342 | 108 |
| shot.126343 | ARAD-4 | 126343 | 126460 | 109 |
| shot.126461 | ARAD-4 | 126461 | 126577 | 110 |
| shot.126578 | ARAD-4 | 126578 | 126694 | 111 |
| shot.126695 | ARAD-4 | 126695 | 126811 | 112 |
| shot.126812 | ARAD-4 | 126812 | 126928 | 113 |
| shot.126929 | ARAD-4 | 126929 | 127046 | 114 |
| shot.127047 | ARAD-4 | 127047 | 127164 | 115 |
| shot.127165 | ARAD-4 | 127165 | 127281 | 116 |
| shot.127282 | ARAD-4 | 127282 | 127398 | 117 |
| shot.127399 | ARAD-4 | 127399 | 127515 | 118 |
| shot.127516 | ARAD-4 | 127516 | 127632 | 119 |
| shot.127633 | ARAD-4 | 127633 | 127737 | 120 |
| shot.127810 | ARAD-4 | 127810 | 127926 | 122 |
| shot.127927 | ARAD-4 | 127927 | 128043 | 123 |
| shot.128044 | ARAD-4 | 128044 | 128160 | 124 |
| shot.128161 | ARAD-4 | 128161 | 128277 | 125 |
| shot.128278 | ARAD-4 | 128278 | 128394 | 126 |
| shot.128395 | ARAD-4 | 128395 | 128511 | 127 |
| shot.128512 | ARAD-4 | 128512 | 128628 | 128 |
| shot.128629 | ARAD-4 | 128629 | 128745 | 129 |
| shot.128746 | ARAD-4 | 128746 | 128862 | 130 |
| shot.128863 | ARAD-4 | 128863 | 128979 | 131 |
| shot.128980 | ARAD-4 | 128980 | 129096 | 132 |
| shot.129097 | ARAD-4 | 129097 | 129213 | 133 |
| shot.129214 | ARAD-4 | 129214 | 129330 | 134 |
| shot.129331 | ARAD-4 | 129331 | 129447 | 135 |



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|-------------|--------|--------|--------|-----|
| shot.129448 | ARAD-4 | 129448 | 129564 | 136 |
| shot.129565 | ARAD-4 | 129565 | 129681 | 137 |
| shot.129682 | ARAD-4 | 129682 | 129798 | 138 |
| shot.129799 | ARAD-4 | 129799 | 129915 | 139 |
| shot.129916 | ARAD-4 | 129916 | 130032 | 140 |
| shot.130033 | ARAD-4 | 130033 | 130149 | 141 |
| shot.130150 | ARAD-4 | 130150 | 130266 | 142 |
| shot.130267 | ARAD-4 | 130267 | 130383 | 143 |
| shot.130384 | ARAD-4 | 130384 | 130500 | 144 |
| shot.130501 | ARAD-4 | 130501 | 130617 | 145 |
| shot.130618 | ARAD-4 | 130618 | 130734 | 146 |
| shot.130735 | ARAD-4 | 130735 | 130804 | 147 |
| shot.131031 | ARAD-4 | 131031 | 131146 | 151 |
| shot.131147 | ARAD-4 | 131147 | 131263 | 152 |
| shot.131264 | ARAD-4 | 131264 | 131380 | 153 |
| shot.131381 | ARAD-4 | 131381 | 131497 | 154 |
| shot.131498 | ARAD-4 | 131498 | 131614 | 155 |
| shot.131615 | ARAD-4 | 131615 | 131731 | 156 |
| shot.131732 | ARAD-4 | 131732 | 131848 | 157 |
| shot.131849 | ARAD-4 | 131849 | 131965 | 158 |
| shot.131966 | ARAD-4 | 131966 | 132082 | 159 |
| shot.132083 | ARAD-4 | 132083 | 132199 | 160 |
| shot.132200 | ARAD-4 | 132200 | 132316 | 161 |
| shot.132320 | ARAD-4 | 132320 | 132434 | 164 |
| shot.132435 | ARAD-4 | 132435 | 132551 | 165 |
| shot.132552 | ARAD-4 | 132552 | 132668 | 166 |
| shot.132669 | ARAD-4 | 132669 | 132786 | 167 |
| shot.132787 | ARAD-4 | 132787 | 132903 | 168 |
| shot.132904 | ARAD-4 | 132904 | 133020 | 169 |
| shot.133021 | ARAD-4 | 133021 | 133074 | 170 |
| shot.133075 | ARAD-4 | 133075 | 133190 | 171 |
| shot.133191 | ARAD-4 | 133191 | 133307 | 172 |
| shot.133308 | ARAD-4 | 133308 | 133424 | 173 |
| shot.133425 | ARAD-4 | 133425 | 133541 | 174 |
| shot.133542 | ARAD-4 | 133542 | 133658 | 175 |
| shot.133659 | ARAD-4 | 133659 | 133775 | 176 |
| shot.133776 | ARAD-4 | 133776 | 133892 | 177 |
| shot.133893 | ARAD-4 | 133893 | 134009 | 178 |
| shot.134010 | ARAD-4 | 134010 | 134126 | 179 |
| shot.134127 | ARAD-4 | 134127 | 134243 | 180 |
| shot.134244 | ARAD-4 | 134244 | 134360 | 181 |
| shot.134361 | ARAD-4 | 134361 | 134477 | 182 |
| shot.134478 | ARAD-4 | 134478 | 134594 | 183 |
| shot.134595 | ARAD-4 | 134595 | 134712 | 184 |
| shot.134713 | ARAD-4 | 134713 | 134829 | 185 |
| shot.134832 | ARAD-4 | 134832 | 134948 | 188 |



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| shot.134949 | ARAD-4 | 134949 | 135065 | 189 |
| shot.135066 | ARAD-4 | 135066 | 135183 | 190 |
| shot.135184 | ARAD-4 | 135184 | 135300 | 191 |
| shot.135301 | ARAD-4 | 135301 | 135417 | 192 |
| shot.135418 | ARAD-4 | 135418 | 135534 | 193 |
| shot.135535 | ARAD-4 | 135535 | 135651 | 194 |
| shot.135652 | ARAD-4 | 135652 | 135768 | 195 |
| shot.135769 | ARAD-4 | 135769 | 135885 | 196 |
| shot.135886 | ARAD-4 | 135886 | 136002 | 197 |
| shot.136007 | ARAD-4 | 136007 | 136122 | 199 |
| shot.136123 | ARAD-4 | 136123 | 136239 | 200 |
| shot.136240 | ARAD-4 | 136240 | 136357 | 201 |
| shot.136362 | ARAD-4 | 136362 | 136477 | 205 |
| shot.136478 | ARAD-4 | 136478 | 136594 | 206 |
| shot.136595 | ARAD-4 | 136595 | 136711 | 207 |
| shot.136712 | ARAD-4 | 136712 | 136828 | 208 |
| shot.136829 | ARAD-4 | 136829 | 136945 | 209 |
| shot.136946 | ARAD-4 | 136946 | 137062 | 210 |
| shot.137063 | ARAD-4 | 137063 | 137179 | 211 |
| shot.137180 | ARAD-4 | 137180 | 137296 | 212 |
| shot.137297 | ARAD-4 | 137297 | 137413 | 213 |
| shot.137418 | ARAD-4 | 137418 | 137533 | 218 |
| shot.137534 | ARAD-4 | 137534 | 137650 | 219 |
| shot.137651 | ARAD-4 | 137651 | 137767 | 220 |
| shot.137768 | ARAD-4 | 137768 | 137884 | 221 |
| shot.137885 | ARAD-4 | 137885 | 138001 | 222 |
| shot.138002 | ARAD-4 | 138002 | 138118 | 223 |
| shot.138119 | ARAD-4 | 138119 | 138235 | 224 |
| shot.138236 | ARAD-4 | 138236 | 138352 | 225 |
| shot.138353 | ARAD-4 | 138353 | 138469 | 226 |
| shot.138470 | ARAD-4 | 138470 | 138586 | 227 |
| shot.138587 | ARAD-4 | 138587 | 138703 | 228 |
| shot.138704 | ARAD-4 | 138704 | 138820 | 229 |
| shot.138821 | ARAD-4 | 138821 | 138937 | 230 |
| shot.138938 | ARAD-4 | 138938 | 139054 | 231 |
| shot.139055 | ARAD-4 | 139055 | 139171 | 232 |
| shot.139172 | ARAD-4 | 139172 | 139288 | 233 |
| shot.139289 | ARAD-4 | 139289 | 139405 | 234 |
| shot.139406 | ARAD-4 | 139406 | 139522 | 235 |
| shot.139523 | ARAD-4 | 139523 | 139639 | 236 |
| shot.139640 | ARAD-4 | 139640 | 139756 | 237 |
| shot.139757 | ARAD-4 | 139757 | 139873 | 238 |
| shot.139874 | ARAD-4 | 139874 | 139990 | 239 |
| shot.139991 | ARAD-4 | 139991 | 140108 | 240 |
| shot.140109 | ARAD-4 | 140109 | 140225 | 241 |
| shot.140226 | ARAD-4 | 140226 | 140342 | 242 |



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| shot.140343 | ARAD-4 | 140343 | 140460 | 243 |
| shot.140461 | ARAD-4 | 140461 | 140577 | 244 |
| shot.140578 | ARAD-4 | 140578 | 140694 | 245 |
| shot.140699 | ARAD-4 | 140699 | 140814 | 249 |
| shot.140815 | ARAD-4 | 140815 | 140931 | 250 |
| shot.140932 | ARAD-4 | 140932 | 141048 | 251 |
| shot.141049 | ARAD-4 | 141049 | 141165 | 252 |
| shot.141166 | ARAD-4 | 141166 | 141282 | 253 |
| shot.141283 | ARAD-4 | 141283 | 141399 | 254 |
| shot.141400 | ARAD-4 | 141400 | 141516 | 255 |
| shot.141517 | ARAD-4 | 141517 | 141633 | 256 |
| shot.141634 | ARAD-4 | 141634 | 141750 | 257 |
| shot.141751 | ARAD-4 | 141751 | 141867 | 258 |
| shot.141868 | ARAD-4 | 141868 | 141984 | 259 |
| shot.141989 | ARAD-4 | 141989 | 142104 | 264 |
| shot.142105 | ARAD-4 | 142105 | 142221 | 265 |
| shot.142226 | ARAD-4 | 142226 | 142341 | 270 |
| shot.142342 | ARAD-4 | 142342 | 142458 | 271 |
| shot.142459 | ARAD-4 | 142459 | 142575 | 272 |
| shot.142576 | ARAD-4 | 142576 | 142692 | 273 |
| shot.142693 | ARAD-4 | 142693 | 142809 | 274 |
| shot.142810 | ARAD-4 | 142810 | 142926 | 275 |
| shot.142927 | ARAD-4 | 142927 | 143043 | 276 |
| shot.143044 | ARAD-4 | 143044 | 143160 | 277 |
| shot.143161 | ARAD-4 | 143161 | 143277 | 278 |
| shot.143278 | ARAD-4 | 143278 | 143394 | 279 |
| shot.143395 | ARAD-4 | 143395 | 143511 | 280 |
| shot.143512 | ARAD-4 | 143512 | 143628 | 281 |
| shot.143629 | ARAD-4 | 143629 | 143745 | 282 |
| shot.143746 | ARAD-4 | 143746 | 143862 | 283 |
| shot.143863 | ARAD-4 | 143863 | 143979 | 284 |
| shot.143980 | ARAD-4 | 143980 | 144096 | 285 |
| shot.144097 | ARAD-4 | 144097 | 144213 | 286 |
| shot.144214 | ARAD-4 | 144214 | 144330 | 287 |
| shot.144334 | ARAD-4 | 144334 | 144449 | 290 |
| shot.144450 | ARAD-4 | 144450 | 144566 | 291 |
| shot.144571 | ARAD-4 | 144571 | 144685 | 295 |
| shot.144686 | ARAD-4 | 144686 | 144802 | 296 |
| shot.144803 | ARAD-4 | 144803 | 144919 | 297 |
| shot.144920 | ARAD-4 | 144920 | 145036 | 298 |
| shot.145037 | ARAD-4 | 145037 | 145052 | 299 |
| shot.145053 | ARAD-4 | 145053 | 145168 | 300 |
| shot.145169 | ARAD-4 | 145169 | 145285 | 301 |
| shot.145286 | ARAD-4 | 145286 | 145402 | 302 |
| shot.145403 | ARAD-4 | 145403 | 145519 | 303 |
| shot.145520 | ARAD-4 | 145520 | 145636 | 304 |



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| shot.145637 | ARAD-4 | 145637 | 145753 | 305 |
| shot.145754 | ARAD-4 | 145754 | 145870 | 306 |
| shot.145871 | ARAD-4 | 145871 | 145987 | 307 |
| shot.145988 | ARAD-4 | 145988 | 146104 | 308 |
| shot.146105 | ARAD-4 | 146105 | 146222 | 309 |
| shot.146223 | ARAD-4 | 146223 | 146339 | 310 |
| shot.146340 | ARAD-4 | 146340 | 146456 | 311 |
| shot.146457 | ARAD-4 | 146457 | 146573 | 312 |
| shot.146574 | ARAD-4 | 146574 | 146690 | 313 |
| shot.146691 | ARAD-4 | 146691 | 146807 | 314 |
| shot.146808 | ARAD-4 | 146808 | 146924 | 315 |
| shot.146925 | ARAD-4 | 146925 | 147041 | 316 |
| shot.147042 | ARAD-4 | 147042 | 147158 | 317 |
| shot.147159 | ARAD-4 | 147159 | 147275 | 318 |
| shot.147276 | ARAD-4 | 147276 | 147392 | 319 |
| shot.147393 | ARAD-4 | 147393 | 147509 | 320 |
| shot.147510 | ARAD-4 | 147510 | 147626 | 321 |
| shot.147627 | ARAD-4 | 147627 | 147744 | 322 |
| shot.147745 | ARAD-4 | 147745 | 147861 | 323 |
| shot.147862 | ARAD-4 | 147862 | 147978 | 324 |
| shot.147979 | ARAD-4 | 147979 | 148095 | 325 |
| shot.148096 | ARAD-4 | 148096 | 148212 | 326 |
| shot.148213 | ARAD-4 | 148213 | 148329 | 327 |
| shot.148330 | ARAD-4 | 148330 | 148446 | 328 |
| shot.148447 | ARAD-4 | 148447 | 148563 | 329 |
| shot.148564 | ARAD-4 | 148564 | 148681 | 330 |
| shot.148682 | ARAD-4 | 148682 | 148798 | 331 |
| shot.148799 | ARAD-4 | 148799 | 148915 | 332 |
| shot.148916 | ARAD-4 | 148916 | 149032 | 333 |
| shot.149033 | ARAD-4 | 149033 | 149149 | 334 |
| shot.149150 | ARAD-4 | 149150 | 149266 | 335 |
| shot.149267 | ARAD-4 | 149267 | 149383 | 336 |
| shot.149384 | ARAD-4 | 149384 | 149500 | 337 |
| shot.149505 | ARAD-4 | 149505 | 149619 | 341 |
| shot.149620 | ARAD-4 | 149620 | 149736 | 342 |
| shot.149737 | ARAD-4 | 149737 | 149853 | 343 |
| shot.149854 | ARAD-4 | 149854 | 149970 | 344 |
| shot.149971 | ARAD-4 | 149971 | 150083 | 345 |
| shot.150093 | ARAD-4 | 150093 | 150208 | 350 |
| shot.150209 | ARAD-4 | 150209 | 150325 | 351 |
| shot.150326 | ARAD-4 | 150326 | 150442 | 352 |
| shot.150443 | ARAD-4 | 150443 | 150561 | 353 |
| shot.150562 | ARAD-4 | 150562 | 150678 | 354 |
| shot.150679 | ARAD-4 | 150679 | 150797 | 355 |
| shot.150798 | ARAD-4 | 150798 | 150893 | 356 |
| shot.150915 | ARAD-4 | 150915 | 151031 | 357 |



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| shot.151036 | ARAD-4 | 151036 | 151152 | 361 |
| shot.151153 | ARAD-4 | 151153 | 151269 | 362 |
| shot.151270 | ARAD-4 | 151270 | 151387 | 363 |
| shot.151388 | ARAD-4 | 151388 | 151504 | 364 |
| shot.151505 | ARAD-4 | 151505 | 151621 | 365 |
| shot.151622 | ARAD-4 | 151622 | 151738 | 366 |
| shot.151739 | ARAD-4 | 151739 | 151855 | 367 |
| shot.151856 | ARAD-4 | 151856 | 151972 | 368 |
| shot.151973 | ARAD-4 | 151973 | 152089 | 369 |
| shot.152090 | ARAD-4 | 152090 | 152206 | 370 |
| shot.152207 | ARAD-4 | 152207 | 152323 | 371 |
| shot.152324 | ARAD-4 | 152324 | 152440 | 372 |
| shot.152441 | ARAD-4 | 152441 | 152557 | 373 |
| shot.152558 | ARAD-4 | 152558 | 152674 | 374 |
| shot.152675 | ARAD-4 | 152675 | 152791 | 375 |
| shot.152792 | ARAD-4 | 152792 | 152908 | 376 |
| shot.152909 | ARAD-4 | 152909 | 153025 | 377 |
| shot.153026 | ARAD-4 | 153026 | 153142 | 378 |
| shot.153143 | ARAD-4 | 153143 | 153259 | 379 |
| shot.153260 | ARAD-4 | 153260 | 153376 | 380 |
| shot.153377 | ARAD-4 | 153377 | 153493 | 381 |
| shot.153494 | ARAD-4 | 153494 | 153610 | 382 |
| shot.153611 | ARAD-4 | 153611 | 153727 | 383 |
| shot.153728 | ARAD-4 | 153728 | 153844 | 384 |
| shot.153845 | ARAD-4 | 153845 | 153961 | 385 |
| shot.153962 | ARAD-4 | 153962 | 154078 | 386 |
| shot.154079 | ARAD-4 | 154079 | 154195 | 387 |
| shot.154196 | ARAD-4 | 154196 | 154312 | 388 |
| shot.154313 | ARAD-4 | 154313 | 154429 | 389 |
| shot.154430 | ARAD-4 | 154430 | 154546 | 390 |
| shot.154547 | ARAD-4 | 154547 | 154663 | 391 |
| shot.154664 | ARAD-4 | 154664 | 154780 | 392 |
| shot.154781 | ARAD-4 | 154781 | 154897 | 393 |
| shot.154898 | ARAD-4 | 154898 | 155014 | 394 |
| shot.155015 | ARAD-4 | 155015 | 155131 | 395 |
| shot.155132 | ARAD-4 | 155132 | 155248 | 396 |
| shot.155249 | ARAD-4 | 155249 | 155365 | 397 |
| shot.155366 | ARAD-4 | 155366 | 155482 | 398 |
| shot.155483 | ARAD-4 | 155483 | 155599 | 399 |
| shot.155600 | ARAD-4 | 155600 | 155716 | 400 |
| shot.155717 | ARAD-4 | 155717 | 155833 | 401 |
| shot.155834 | ARAD-4 | 155834 | 155950 | 402 |
| shot.155951 | ARAD-4 | 155951 | 156067 | 403 |
| shot.156068 | ARAD-4 | 156068 | 156185 | 404 |
| shot.156186 | ARAD-4 | 156186 | 156304 | 405 |
| shot.156305 | ARAD-4 | 156305 | 156421 | 406 |



|             |        |        |        |     |
|-------------|--------|--------|--------|-----|
| shot.156422 | ARAD-4 | 156422 | 156538 | 407 |
| shot.156539 | ARAD-4 | 156539 | 156655 | 408 |
| shot.156656 | ARAD-4 | 156656 | 156772 | 409 |
| shot.156773 | ARAD-4 | 156773 | 156889 | 410 |
| shot.156890 | ARAD-4 | 156890 | 157006 | 411 |
| shot.157007 | ARAD-4 | 157007 | 157123 | 412 |
| shot.157124 | ARAD-4 | 157124 | 157240 | 413 |
| shot.157245 | ARAD-4 | 157245 | 157360 | 417 |
| shot.157361 | ARAD-4 | 157361 | 157477 | 418 |
| shot.157478 | ARAD-4 | 157478 | 157594 | 419 |
| shot.157598 | ARAD-4 | 157598 | 157713 | 422 |
| shot.157714 | ARAD-4 | 157714 | 157830 | 423 |
| shot.157831 | ARAD-4 | 157831 | 157947 | 424 |
| shot.157948 | ARAD-4 | 157948 | 158064 | 425 |
| shot.158065 | ARAD-4 | 158065 | 158181 | 426 |
| shot.158182 | ARAD-4 | 158182 | 158298 | 427 |
| shot.158299 | ARAD-4 | 158299 | 158415 | 428 |
| shot.158416 | ARAD-4 | 158416 | 158532 | 429 |
| shot.158533 | ARAD-4 | 158533 | 158650 | 430 |
| shot.158651 | ARAD-4 | 158651 | 158767 | 431 |
| shot.158768 | ARAD-4 | 158768 | 158884 | 432 |
| shot.158885 | ARAD-4 | 158885 | 159001 | 433 |
| shot.159002 | ARAD-4 | 159002 | 159118 | 434 |
| shot.159119 | ARAD-4 | 159119 | 159235 | 435 |
| shot.159236 | ARAD-4 | 159236 | 159352 | 436 |
| shot.159353 | ARAD-4 | 159353 | 159469 | 437 |
| shot.159470 | ARAD-4 | 159470 | 159586 | 438 |
| shot.159587 | ARAD-4 | 159587 | 159703 | 439 |
| shot.159704 | ARAD-4 | 159704 | 159820 | 440 |
| shot.159821 | ARAD-4 | 159821 | 159937 | 441 |
| shot.159938 | ARAD-4 | 159938 | 160055 | 442 |
| shot.160056 | ARAD-4 | 160056 | 160172 | 443 |
| shot.160173 | ARAD-4 | 160173 | 160289 | 444 |
| shot.160290 | ARAD-4 | 160290 | 160406 | 445 |
| shot.160407 | ARAD-4 | 160407 | 160523 | 446 |
| shot.160524 | ARAD-4 | 160524 | 160564 | 446 |



**Appendix 15**  
**ARAD Missing Shots Log**



| Shot#     | 1st Missing | Last Missing | MCS Line # | Problem       |
|-----------|-------------|--------------|------------|---------------|
| 3327      | trace 1     | trace 124    | 201        |               |
| 3388      | 1           | 124          | 201        |               |
| 4650      | 1           | 124          | 135        | tape eject    |
| 4651      | 1           | 124          |            |               |
| 4652      | 1           | 124          |            |               |
| 4653      | 1           | 124          |            |               |
| 4654      | 1           | 124          |            |               |
| 4655      | 1           | 124          |            |               |
| 5775      | 1           | 124          | 102        |               |
| 5778      | 1           | 124          |            |               |
| 6213      | 63          | 124          | 69         |               |
| 7119      | 1           | 124          | 36         | tape eject    |
| 7120      | 1           | 124          |            |               |
| 7121      | 1           | 124          |            |               |
| 7122      | 1           | 124          |            |               |
| 7123      | 1           | 124          |            |               |
| 7124      | 1           | 124          |            |               |
| 7125      | 1           | 124          |            |               |
| 7126      | 1           | 124          |            |               |
| 7338      | 1           | 124          | 36         |               |
| 7648      | 46          | 124          | T36/3      |               |
| 7649      | 80          | 124          |            |               |
| 7650      | 79          | 124          |            |               |
| 7686      | 1           | 124          | T36/3      | tape eject    |
| 7687      | 1           | 124          |            |               |
| 7688      | 1           | 124          |            |               |
| 7689      | 1           | 124          |            |               |
| 7690      | 1           | 124          |            |               |
| 7886      | 1           | 124          | 3          |               |
| 8155      | 8           | 8            | 3          |               |
| 8403      | 1           | 124          | T 3/OBH    | Start OBH Ops |
| 8404      | 1           | 124          |            |               |
| 8405      | 1           | 124          |            |               |
| 8406      | 1           | 124          |            |               |
| 8407      | 1           | 124          |            |               |
| 8408      | 1           | 124          |            |               |
| 8409      | 1           | 124          |            |               |
| 8410      | 1           | 124          |            |               |
| 8411      | 1           | 124          |            |               |
| 8412      | 1           | 124          |            |               |
| 8413-8426 | 1           | 124          |            |               |
| 8427      | 1           | 124          |            |               |
| 8428      | 1           | 124          |            |               |
| 8429      | 1           | 124          |            |               |
| 8430      | 1           | 124          |            |               |
| 8431      | 1           | 124          |            |               |
| 8432      | 1           | 124          |            |               |
| 8433      | 1           | 124          |            |               |
| 8434      | 1           | 124          |            |               |



|       |    |     |           |            |
|-------|----|-----|-----------|------------|
| 8435  | 1  | 124 |           |            |
| 8436  | 1  | 124 |           |            |
| 8996  | 63 | 124 | OBH       |            |
| 9075  | 1  | 124 | OBH       |            |
| 9220  | 1  | 124 | OBH       |            |
| 9221  | 1  | 124 |           |            |
| 9222  | 1  | 124 |           |            |
| 9223  | 1  | 124 |           |            |
| 9224  | 1  | 124 |           |            |
| 9225  | 1  | 124 |           |            |
| 9226  | 1  | 124 |           |            |
| 9227  | 1  | 124 |           |            |
| 9228  | 1  | 124 |           |            |
| 9229  | 1  | 124 |           |            |
| 9230  | 1  | 124 |           |            |
| 9231  | 1  | 124 |           |            |
| 9232  | 1  | 124 |           |            |
| 9233  | 1  | 124 |           |            |
| 9234  | 1  | 124 |           |            |
| 9235  | 1  | 124 |           |            |
| 9236  | 1  | 124 |           |            |
| 9909  | 1  | 124 | T 199/166 |            |
| 9910  | 1  | 124 |           |            |
| 9911  | 1  | 124 |           |            |
| 9912  | 1  | 124 |           |            |
| 9913  | 1  | 124 |           |            |
| 12266 | 1  | 124 | 103       |            |
| 12515 | 1  | 124 | 67        | Reboot     |
| 12516 | 1  | 124 |           |            |
| 12517 | 1  | 124 |           |            |
| 12518 | 1  | 124 |           |            |
| 12519 | 1  | 124 |           |            |
| 12520 | 1  | 124 |           |            |
| 12521 | 1  | 124 |           |            |
| 12522 | 1  | 124 |           |            |
| 12523 | 1  | 124 |           |            |
| 12524 | 1  | 124 |           |            |
| 12525 | 1  | 124 |           |            |
| 12526 | 1  | 124 |           |            |
| 12527 | 1  | 124 |           |            |
| 12528 | 1  | 124 |           |            |
| 12529 | 1  | 124 |           |            |
| 12530 | 1  | 124 |           |            |
| 12531 | 1  | 124 |           |            |
| 14296 | 1  | 124 | 1         | tape eject |
| 14297 | 1  | 124 |           |            |
| 14298 | 1  | 124 |           |            |
| 14299 | 1  | 124 |           |            |
| 14300 | 1  | 124 |           |            |
| 14301 | 1  | 124 |           |            |



|         |     |     |         |              |
|---------|-----|-----|---------|--------------|
| 14448   | 1   | 124 | 1       | not recorded |
| 14600   | 1   | 124 | T 1/32  | not recorded |
| 14669   | 1   | 124 | T 1/32  |              |
| 14974   | 1   | 124 | 32      |              |
| 14975   | 1   | 124 |         |              |
| 14976   | 1   | 124 |         |              |
| 14977   | 1   | 124 |         |              |
| 16665   | 1   | 124 | 38      |              |
| 17261   | 68  | 124 | 7       | shot bad     |
| 18001   | 104 | 124 | 40      | shot bad     |
| 18337   | 51  | 124 | T 40/9  | shot bad     |
| 18549   | 1   | 124 | 9       | not recorded |
| 20914   | 1   | 124 | 44      | tape eject   |
| 20915   | 1   | 124 |         |              |
| 20916   | 1   | 124 |         |              |
| 21795   | 5   | 124 | 13      | SQTP error   |
| 21917   | 1   | 124 | 13      | SQTP error   |
| 21919   | 1   | 124 | 13      | SQTP error   |
| 22307   | 92  | 124 | 46      | SQTP error   |
| 23233   | 1   | 124 | 15      |              |
| 23234   | 1   | 124 |         |              |
| 23236   | 1   | 124 |         |              |
| 23676   | 34  | 124 | T 15/48 | bad shot     |
| 24499   | 1   | 124 | 17      | tape eject   |
| 24500   | 1   | 124 |         |              |
| 24501   | 1   | 124 |         |              |
| 25085   | 1   | 124 | T 17/50 | not recorded |
| 25878   | 59  | 124 | 50      | SQTP error   |
| 25956   | 116 | 124 | T 50/19 | SQTP error   |
| 27070   | 1   | 124 | 52      |              |
| 27190   | 1   | 124 | 52      | tape eject   |
| 27191   | 1   | 124 |         |              |
| 27192   | 1   | 124 |         |              |
| 27193   | 1   | 124 |         |              |
| 27194   | 1   | 124 |         |              |
| 27302   | 65  | 124 | T 52/21 | SQTP error   |
| 27530   | 1   | 124 | 21      | tape eject   |
| 27531   | 1   | 124 |         |              |
| 27532   | 1   | 124 |         |              |
| 27749   | 117 | 124 | 21      | SQTP error   |
| 27985   | 85  | 124 | 21      | SQTP error   |
| 28371   | 84  | 124 | 54      | SQTP error   |
| 28426   | 94  | 124 | 54      | SQTP error   |
| 28876   | 68  | 124 | T 54/23 | SQTP error   |
| 28885   | 52  | 124 | T 54/23 | SQTP error   |
| 29549   | 49  | 124 | T 23/56 | SQTP error   |
| 31885   | 113 | 124 | T 58/27 | SQTP error   |
| 31896   | 46  | 124 | T 58/27 | SQTP error   |
| 32902   | 83  | 124 | 62      | SQTP error   |
| 32903/4 | 124 | 124 | 62      | SQTP error   |



|       |     |     |         |              |
|-------|-----|-----|---------|--------------|
| 33904 | 120 | 124 |         |              |
| 33906 | 117 | 124 |         |              |
| 33912 | 87  | 124 | 29      | SQTP error   |
| 33913 | 117 | 124 |         | SQTP error   |
| 33914 | 115 | 124 |         | SQTP error   |
| 34475 | 1   | 124 | 60      | tape eject   |
| 34476 | 1   | 124 |         |              |
| 34477 | 1   | 124 |         |              |
| 35148 | 1   | 124 | 31      | tape eject   |
| 35149 | 1   | 124 |         |              |
| 35150 | 1   | 124 |         |              |
| 35151 | 1   | 124 |         |              |
| 35595 | 1   | 124 | T 31/64 | bad shot     |
| 36160 | 1   | 124 | 64      | tape eject   |
| 36161 | 1   | 124 |         |              |
| 36162 | 1   | 124 |         |              |
| 36163 | 1   | 124 |         |              |
| 36386 | 77  | 124 | T 64/33 | tape eject   |
| 36401 | 1   | 124 | T 64/33 | not recorded |
| 36723 | 1   | 124 | 39      | tape eject   |
| 36724 | 1   | 124 |         |              |
| 36725 | 1   | 124 |         |              |
| 37172 | 1   | 124 | T 33/66 | tape eject   |
| 37173 | 1   | 124 |         |              |
| 37174 | 1   | 124 |         |              |
| 37175 | 1   | 124 |         |              |
| 37849 | 106 | 124 | T 66/35 | SQTP error   |
| 38016 | 115 | 124 | 35      | SQTP error   |
| 38019 | 73  | 124 | 35      | SQTP error   |
| 38022 | 82  | 124 | 35      | SQTP error   |
| 38027 | 75  | 124 | 35      | SQTP error   |
| 38030 | 95  | 124 | 35      | SQTP error   |
| 38035 | 99  | 124 | 35      | SQTP error   |
| 38036 | 102 | 124 |         |              |
| 38042 | 66  | 124 | 35      | SQTP error   |
| 38519 | 1   | 124 | 35      | tape eject   |
| 38520 | 1   | 124 |         |              |
| 38521 | 1   | 124 |         |              |
| 38522 | 1   | 124 |         |              |
| 39753 | 1   | 124 | 37      | tape eject   |
| 39754 | 1   | 124 |         |              |
| 39755 | 1   | 124 |         |              |
| 39756 | 1   | 124 |         |              |
| 39757 | 1   | 124 |         |              |
| 40814 | 1   | 124 | T 4/39  | bad shot     |
| 40877 | 1   | 124 | T 4/39  | tape eject   |
| 40878 | 1   | 124 |         |              |
| 40879 | 1   | 124 |         |              |
| 41426 | 58  | 58  | 39      |              |
| 41550 | 1   | 124 | T 39/6  | tape eject   |



|       |     |     |         |              |
|-------|-----|-----|---------|--------------|
| 41551 | 1   | 124 |         |              |
| 41552 | 1   | 124 |         |              |
| 41553 | 1   | 124 |         |              |
| 41554 | 1   | 124 |         |              |
| 41869 | 41  | 124 | 6       | SQTP error   |
| 42225 | 1   | 124 | 6       | tape eject   |
| 42226 | 1   | 124 |         |              |
| 42227 | 1   | 124 |         |              |
| 42228 | 1   | 124 |         |              |
| 42340 | 1   | 124 | T 6/42  | tape eject   |
| 42341 | 1   | 124 |         |              |
| 42342 | 1   | 124 |         |              |
| 42343 | 1   | 124 |         |              |
| 42344 | 1   | 124 |         |              |
| 43054 | 1   | 124 | T 41/8  | SQTP Error   |
| 43267 | 113 | 124 | 8       | SQTP Error   |
| 43272 | 57  | 124 | 8       | SQTP Error   |
| 43839 | 1   | 124 | T 8/43  |              |
| 44287 | 1   | 124 | 43      | tape eject   |
| 44288 | 1   | 124 |         |              |
| 44289 | 1   | 124 |         |              |
| 44290 | 1   | 124 |         |              |
| 44291 | 1   | 124 |         |              |
| 44352 | 1   | 124 | 43      | not recorded |
| 45748 | 1   | 124 |         | tape eject   |
| 45749 | 1   | 124 |         |              |
| 45750 | 1   | 124 |         |              |
| 45751 | 1   | 124 |         |              |
| 45752 | 1   | 124 |         |              |
| 46199 | 1   | 124 | 12      | tape eject   |
| 46200 | 1   | 124 |         |              |
| 46201 | 1   | 124 |         |              |
| 46202 | 1   | 124 |         |              |
| 46985 | 1   | 124 | 47      | tape eject   |
| 46986 | 1   | 124 |         |              |
| 46987 | 1   | 124 |         |              |
| 46988 | 1   | 124 |         |              |
| 46989 | 1   | 124 |         |              |
| 47641 | 1   | 124 | T 47/14 |              |
| 48120 | 35  | 124 | 14      | SQTP Error   |
| 48316 | 92  | 124 | 49      | SQTP Error   |
| 48719 | 1   | 124 | 49      | not recorded |
| 49567 | 43  | 124 | 16      | SQTP Error   |
| 49568 | 2   | 124 | 16      | SQTP Error   |
| 49570 | 1   | 124 | 16      | tape parity  |
| 49572 | 1   | 124 | 16      | tape parity  |
| 49575 | 1   | 124 | 16      | tape parity  |
| 49577 | 1   | 124 | 16      | tape parity  |
| 49581 | 1   | 124 | 16      | tape parity  |
| 49582 | 1   | 124 | 16      | tape parity  |



|       |     |     |         |               |
|-------|-----|-----|---------|---------------|
| 49584 | 1   | 124 | 16      | tape parity   |
| 49588 | 85  | 124 | 16      | tape parity   |
| 49594 | 51  | 124 | 16      | tape ejected  |
| 49595 | 1   | 124 | 16      |               |
| 49707 | 1   | 124 | T 16/51 |               |
| 49711 | 1   | 124 | T 16/51 |               |
| 49883 | 54  | 124 | 51      | tape parity   |
| 50521 | 1   | 124 | T 51/18 | error         |
| 50643 | 1   | 124 | 18      | error         |
| 52166 | 1   | 124 |         | bad shot      |
| 53072 | 1   | 124 | 55      | tape eject    |
| 53073 | 1   | 124 |         |               |
| 53074 | 1   | 124 |         |               |
| 53697 | 123 | 124 | 22      | SQTP error    |
| 55510 | 1   | 124 | 24      | acquisition E |
| 56474 | 1   | 124 | T 59/28 | bad shot      |
| 57443 | 43  | 124 | 61      |               |
| 58003 | 1   | 124 | 28      | tape eject    |
| 58004 | 1   | 124 |         |               |
| 58005 | 1   | 124 |         |               |
| 58006 | 1   | 124 |         |               |
| 58007 | 1   | 124 |         |               |
| 58497 | 100 | 124 | 28      | bad shot      |
| 59015 | 1   | 124 | 63      | bad shot      |
| 59016 | 1   | 124 |         | missing shot  |
| 59017 | 1   | 124 |         | missing shot  |
| 59212 | 9   | 124 | 63      | SQTP error    |
| 59798 | 97  | 124 |         | SQTP error    |
| 59912 | 1   | 124 | 30      | tape eject    |
| 59913 | 1   | 124 | 30      |               |
| 59915 | 1   | 124 | 30      |               |
| 60283 | 1   | 124 | 65      | not recorded  |
| 60475 | 1   | 124 | 65      | tape eject    |
| 60476 | 1   | 124 | 65      |               |
| 60477 | 1   | 124 | 65      |               |
| 60478 | 1   | 124 | 65      |               |
| 61705 | 1   | 124 | 71      | tape eject    |
| 61706 | 1   | 124 | 71      |               |
| 61707 | 1   | 124 | 71      |               |
| 61708 | 1   | 124 | 71      |               |
| 62495 | 1   | 124 | 90      | bad shot      |
| 62618 | 1   | 124 | 90      | bad shot      |
| 62717 | 52  | 124 | T 90/73 | SQTP error    |
| 63165 | 1   | 124 | 73      | tape eject    |
| 63166 | 1   | 124 |         |               |
| 63167 | 1   | 124 |         |               |
| 63168 | 1   | 124 |         |               |
| 63727 | 1   | 124 | T 73/92 | tape eject    |
| 63728 | 1   | 124 |         |               |
| 63729 | 1   | 124 |         |               |



|       |     |     |          |             |
|-------|-----|-----|----------|-------------|
| 63730 | 1   | 124 |          |             |
| 63861 | 59  | 124 | 92       | SQIP error  |
| 64402 | 1   | 124 | T 92/75  | tape eject  |
| 64403 | 1   | 124 |          |             |
| 64404 | 1   | 124 |          |             |
| 64405 | 1   | 124 |          |             |
| 66083 | 76  | 124 | 77       | SQIP error  |
| 66791 | 1   | 124 | 96       |             |
| 67749 | 1   | 124 | 79       | shot missed |
| 67907 | 1   | 124 | T 79/98  |             |
| 68551 | 43  | 124 | 98       | bad shot    |
| 68853 | 99  | 124 | 81       | bad shot    |
| 69111 | 1   | 124 | 81       | tape eject  |
| 69112 | 1   | 124 |          |             |
| 69113 | 1   | 124 |          |             |
| 69114 | 1   | 124 |          |             |
| 69132 | 46  | 124 | 81       | SQIP error  |
| 69133 | 74  | 124 | 81       | SQIP error  |
| 69145 | 100 | 124 | 81       | SQIP error  |
| 69674 | 1   | 124 | 104      | tape eject  |
| 69675 | 1   | 124 |          |             |
| 69676 | 1   | 124 |          |             |
| 69677 | 1   | 124 |          |             |
| 69678 | 1   | 124 |          |             |
| 70014 | 1   | 124 | T 104/83 | tape eject  |
| 70015 | 1   | 124 |          |             |
| 70016 | 1   | 124 |          |             |
| 70017 | 1   | 124 |          |             |
| 70240 | 1   | 124 | 83       | tape eject  |
| 70241 | 1   | 124 |          |             |
| 70242 | 1   | 124 |          |             |
| 70243 | 1   | 124 |          |             |
| 70244 | 1   | 124 |          |             |
| 70356 | 1   | 124 | 83       | tape eject  |
| 70357 | 1   | 124 | 83       | tape eject  |
| 70358 | 1   | 124 |          |             |
| 70359 | 1   | 124 |          |             |
| 70360 | 1   | 124 |          |             |
| 70361 | 1   | 124 |          |             |
| 70472 | 1   | 124 | 83       | tape eject  |
| 70473 | 1   | 124 | 83       | tape eject  |
| 70474 | 1   | 124 |          |             |
| 70579 | 53  | 124 | 83       |             |
| 70697 | 1   | 124 | 106      | reboot      |
| 70698 | 1   | 124 |          |             |
| 70699 | 1   | 124 |          |             |
| 70700 | 1   | 124 |          |             |
| 70701 | 1   | 124 |          |             |
| 70702 | 1   | 124 |          |             |
| 70703 | 1   | 124 |          |             |



|             |     |        |          |               |
|-------------|-----|--------|----------|---------------|
| 70704       | 1   | 124    |          |               |
| 70705       | 1   | 124    |          |               |
| 70706       | 1   | 124    |          |               |
| 70707-71043 |     | reboot |          |               |
| 71044       | 1   | 124    |          |               |
| 71045       | 1   | 124    |          |               |
| 71046       | 1   | 124    |          |               |
| 71047       | 1   | 124    |          |               |
| 71048       | 1   | 124    |          |               |
| 71049       | 1   | 124    |          |               |
| 71050       | 1   | 124    |          |               |
| 71051       | 1   | 124    |          |               |
| 71052       | 1   | 124    |          |               |
| 71053       | 1   | 124    |          | reboot        |
| 71135       | 96  | 124    | 106      | SQTP error    |
| 71296       | 1   | 124    | 106      | bad shot      |
| 71297       | 1   | 124    |          | bad shot      |
| 71298       | 1   | 124    |          | bad shot      |
| 71539       | 1   | 124    | 106      |               |
| 71540       | 1   | 124    | 106      | acquisition E |
| 71541       | 1   | 124    |          |               |
| 71588       | 1   | 124    | 106      | acquisition E |
| 71683       | 1   | 124    | T 106/85 | system reset  |
| 71684       | 1   | 124    | T 106/85 |               |
| 71685       | 1   | 124    |          |               |
| 71686       | 1   | 124    |          |               |
| 71687       | 1   | 124    |          |               |
| 71688       | 1   | 124    |          |               |
| 71689       | 1   | 124    |          |               |
| 71807       | 1   | 124    | 85       | bad shot      |
| 72078       | 116 | 124    | 85       | SQTP error    |
| 72264       | 53  | 124    | 85       | SQTP error    |
| 72677       | 1   | 124    | 108      | acquisition E |
| 74031       | 53  | 124    | 110      | SQTP error    |
| 74163       | 32  | 124    | 110      | SQTP error    |
| 75219       | 1   | 124    | T 89/68  | acquisition E |
| 75904       | 1   | 124    | T 68/91  | tape eject    |
| 75905       | 1   | 124    |          |               |
| 75906       | 1   | 124    |          |               |
| 75956       | 86  | 124    | 91       | SQTP error    |
| 76373       | 1   | 124    | 91       | tape eject    |
| 76374       | 1   | 124    |          |               |
| 76375       | 1   | 124    |          |               |
| 76376       | 1   | 124    |          |               |
| 76475       | 60  | 124    | 91       | SQTP error    |
| 76483       | 58  | 124    | 91       | SQTP error    |
| 76485       | 103 | 124    | 91       | SQTP error    |
| 76486       | 76  | 124    |          | SQTP error    |
| 76493       | 1   | 124    | 91       | tape eject    |
| 76494       | 1   | 124    |          |               |



|       |     |     |          |               |
|-------|-----|-----|----------|---------------|
| 76495 | 1   | 124 |          |               |
| 76496 | 1   | 124 |          |               |
| 76861 | 1   | 124 | 70       | acquisition E |
| 77196 | 1   | 124 | 70       | acquisition F |
| 80061 | 1   | 124 | 74       |               |
| 80124 | 1   | 124 | 74       | tape eject    |
| 80125 | 1   | 124 |          |               |
| 80126 | 1   | 124 |          |               |
| 80127 | 1   | 124 |          |               |
| 80243 | 1   | 124 | 74       | tape eject    |
| 80244 | 1   | 124 |          |               |
| 80245 | 1   | 124 |          |               |
| 80246 | 1   | 124 |          |               |
| 80615 | 1   | 124 | 97       | acquisition F |
| 82002 | 1   | 124 | 99       | tape eject    |
| 82003 | 1   | 124 |          |               |
| 82004 | 1   | 124 |          |               |
| 82712 | 68  | 124 | 78       | SQTP error    |
| 82713 | 53  | 124 |          | SQTP error    |
| 82832 | 48  | 124 | 78       | SQTP error    |
| 82966 | 104 | 124 | 78       | SQTP error    |
| 83173 | 1   | 124 | 78       | tape eject    |
| 83174 | 1   | 124 |          |               |
| 83175 | 1   | 124 |          |               |
| 83876 | 1   | 124 |          | tape eject    |
| 83877 | 1   | 124 |          |               |
| 83878 | 1   | 124 |          |               |
| 83879 | 1   | 124 |          |               |
| 83880 | 1   | 124 |          |               |
| 84933 | 1   | 124 | 103      | tape eject    |
| 84934 | 1   | 124 |          |               |
| 84935 | 1   | 124 |          |               |
| 84936 | 1   | 124 |          |               |
| 85520 | 1   | 124 | 82       | tape eject    |
| 85521 | 1   | 124 |          |               |
| 85522 | 1   | 124 |          |               |
| 86568 | 118 | 124 | 105      | SQTP error    |
| 86571 | 79  | 124 | 105      | SQTP error    |
| 86685 | 124 | 124 | 105      | SQTP error    |
| 87441 | 85  | 124 | 84       | SQTP error    |
| 88095 | 1   | 124 | T 84/107 | tape eject    |
| 88096 | 1   | 124 |          |               |
| 88097 | 1   | 124 |          |               |
| 88098 | 1   | 124 |          |               |
| 88099 | 1   | 124 |          |               |
| 88100 | 1   | 124 |          |               |
| 88101 | 1   | 124 |          |               |
| 88947 | 83  | 124 | 86       | SQTP error    |
| 88953 | 64  | 124 | 86       | SQTP error    |
| 88962 | 89  | 124 | 86       | SQTP error    |



|        |    |     |           |               |
|--------|----|-----|-----------|---------------|
| 88969  | 98 | 124 | 86        | SOT error     |
| 90523  | 1  | 124 | 132       | bad shot      |
| 93058  | 1  | 124 | 113       | acquisition E |
| 93061  | 1  | 124 | 113       | acquisition E |
| 93252  | 1  | 124 | 136       | tape eject    |
| 93253  | 1  | 124 |           |               |
| 93254  | 1  | 124 |           |               |
| 93255  | 1  | 124 |           |               |
| 93606  | 1  | 124 | 136       | tape eject    |
| 93607  | 1  | 124 |           |               |
| 93608  | 1  | 124 |           |               |
| 93609  | 1  | 124 |           |               |
| 93610  | 1  | 124 |           |               |
| 93611  | 1  | 124 |           |               |
| 94123  | 1  | 124 | 115       |               |
| 96674  | 1  | 124 | T 117/140 | tape eject    |
| 96675  | 1  | 124 |           |               |
| 96676  | 1  | 124 |           |               |
| 96677  | 1  | 124 |           |               |
| 97223  | 1  | 124 | 140       | not recorded  |
| 97263  | 1  | 124 | 140       | tape eject    |
| 97264  | 1  | 124 |           |               |
| 97265  | 1  | 124 |           |               |
| 97266  | 1  | 124 |           |               |
| 97267  | 1  | 124 |           |               |
| 97416  | 1  | 124 | 119       | tape eject    |
| 97617  | 1  | 124 |           |               |
| 97618  | 1  | 124 |           |               |
| 97619  | 1  | 124 |           |               |
| 97620  | 1  | 124 |           |               |
| 97971  | 1  | 124 | 119       | tape eject    |
| 97972  | 1  | 124 |           |               |
| 97973  | 1  | 124 |           |               |
| 97974  | 1  | 124 |           |               |
| 97975  | 1  | 124 |           |               |
| 98816  | 1  | 124 | 121       | acquisition E |
| 99731  | 1  | 124 | 144       | tape eject    |
| 99732  | 1  | 124 |           |               |
| 99733  | 1  | 124 |           |               |
| 99734  | 1  | 124 |           |               |
| 99735  | 1  | 124 |           |               |
| 101701 | 1  | 124 | 146       | acquisition E |
| 103983 | 1  | 124 | T 127/150 | tape eject    |
| 103984 | 1  | 124 |           |               |
| 103985 | 1  | 124 |           |               |
| 104686 | 1  | 124 |           |               |
| 104687 | 1  | 124 |           |               |
| 104688 | 1  | 124 |           |               |
| 104735 | 1  | 124 | 129       | bad shot      |
| 105040 | 1  | 124 | 129       | tape eject    |



|        |    |     |           |               |
|--------|----|-----|-----------|---------------|
| 105041 | 1  | 124 |           |               |
| 105042 | 1  | 124 |           |               |
| 105043 | 1  | 124 |           |               |
| 105393 | 1  | 124 | T 129/152 | bad shot      |
| 105394 | 1  | 124 |           |               |
| 105628 | 1  | 124 | 152       | tape eject    |
| 105629 | 1  | 124 |           |               |
| 105630 | 1  | 124 |           |               |
| 105631 | 1  | 124 |           |               |
| 106683 | 1  | 124 | 131       | tape eject    |
| 106684 | 1  | 124 |           |               |
| 106685 | 1  | 124 |           |               |
| 106686 | 1  | 124 |           |               |
| 106687 | 1  | 124 |           |               |
| 106688 | 1  | 124 |           |               |
| 106883 | 1  | 124 | T 131/112 | lost shot     |
| 106899 | 1  | 124 | T 131/112 |               |
| 107485 | 1  | 124 | 112       | lost shot     |
| 110785 | 1  | 124 | 116       | tape eject    |
| 110786 | 1  | 124 |           |               |
| 110787 | 1  | 124 |           |               |
| 111489 | 1  | 124 | 141       | tape eject    |
| 111490 | 1  | 124 |           |               |
| 111491 | 1  | 124 |           |               |
| 111492 | 1  | 124 |           |               |
| 111493 | 1  | 124 |           |               |
| 112191 | 1  | 124 | 118       | lost shot     |
| 112195 | 1  | 124 | 118       | tape eject    |
| 112196 | 1  | 124 |           |               |
| 112197 | 1  | 124 |           |               |
| 112664 | 1  | 124 | 143       | tape eject    |
| 112665 | 1  | 124 |           |               |
| 112666 | 1  | 124 |           |               |
| 112668 | 1  | 124 | 143       |               |
| 113102 | 13 | 124 | 143       | SQTP error    |
| 113367 | 1  | 124 | 120       | tape eject    |
| 113368 | 1  | 124 |           |               |
| 113369 | 1  | 124 |           |               |
| 113370 | 1  | 124 |           |               |
| 114891 | 1  | 124 | 122       | tape eject    |
| 114892 | 1  | 124 |           |               |
| 114893 | 1  | 124 |           |               |
| 114894 | 1  | 124 |           |               |
| 114895 | 1  | 124 |           |               |
| 115246 | 1  | 124 | 122       | tape eject    |
| 115247 | 1  | 124 |           |               |
| 115248 | 1  | 124 |           |               |
| 115249 | 1  | 124 |           |               |
| 115277 | 1  | 124 | T 122/147 | acquisition E |
| 115278 | 1  | 124 |           |               |



|               |    |        |           |               |
|---------------|----|--------|-----------|---------------|
| 115279        | 1  | 124    |           |               |
| 115280        | 1  | 124    |           |               |
| 115281        | 1  | 124    |           |               |
| 115282        | 1  | 124    |           |               |
| 115283        | 1  | 124    |           |               |
| 115284        | 1  | 124    |           |               |
| 115285        | 1  | 124    |           |               |
| 115286        | 1  | 124    |           |               |
| 115287        | 1  | 124    |           |               |
| 115288        | 1  | 124    |           |               |
| 115289        | 1  | 124    |           |               |
| 115290        | 1  | 124    |           |               |
| 115291        | 1  | 124    |           |               |
| 115292        | 1  | 124    |           |               |
| 115293        | 1  | 124    |           |               |
| 115294        | 1  | 124    |           |               |
| 115295        | 1  | 124    |           |               |
| 115312        | 1  | 124    | T 122/147 | tape eject    |
| 115313        | 1  | 124    |           |               |
| 115314        | 1  | 124    |           |               |
| 115315        | 1  | 124    |           |               |
| 115401        | 33 | 124    | 147       | SQTP error    |
| 115402        | 1  | 124    |           |               |
| 115636        | 1  | 124    | 147       | tape eject    |
| 115637        | 1  | 124    |           |               |
| 115638        | 1  | 124    |           |               |
| 115790        | 1  | 124    | 147       | acquisition E |
| 115853        | 96 | 124    | 147       | SQTP error    |
| 115860        | 1  | 124    | 147       |               |
| 115861        | 1  | 124    |           |               |
| 115902        | 1  | 124    | 147       |               |
| 115985        | 1  | 124    | T 147/124 | reboot        |
| 115986        | 1  | 124    |           |               |
| 115987        | 1  | 124    |           |               |
| 115988        | 1  | 124    |           |               |
| 115989        | 1  | 124    |           |               |
| 115990        | 1  | 124    |           |               |
| 115991        | 1  | 124    |           |               |
| 115992        | 1  | 124    |           |               |
| 115993        | 1  | 124    |           |               |
| 115994        | 1  | 124    |           |               |
| 115994-116016 |    | reboot |           |               |
| 116017        | 1  | 124    |           |               |
| 116018        | 1  | 124    |           |               |
| 116019        | 1  | 124    |           |               |
| 116020        | 1  | 124    |           |               |
| 116021        | 1  | 124    |           |               |
| 116022        | 1  | 124    |           |               |
| 116023        | 1  | 124    |           |               |
| 116024        | 1  | 124    |           |               |



|               |     |              |           |               |
|---------------|-----|--------------|-----------|---------------|
| 116025        | 1   | 124          |           |               |
| 116026        | 1   | 124          |           | reboot        |
| 116963        | 1   | 124          | 149       | tape eject    |
| 116964        | 1   | 124          |           |               |
| 116965        | 1   | 124          |           |               |
| 116966        | 1   | 124          |           |               |
| 116967        | 1   | 124          |           |               |
| 116968        | 1   | 124          |           |               |
| 117319        | 1   | 124          | 149       | tape eject    |
| 117320        | 1   | 124          |           |               |
| 117321        | 1   | 124          |           |               |
| 117322        | 1   | 124          |           |               |
| 118608        | 1   | 124          | 151       | tape eject    |
| 118609        | 1   | 124          |           |               |
| 118610        | 1   | 124          |           |               |
| 118611        | 1   | 124          |           |               |
| 122603        | 1   | 124          | T 180/157 | not recorded  |
| 122898        | 70  | 124          | 157       | SQTP error    |
| 123212        | 1   | 124          | 157       | acquisition E |
| 124112        | 1   | 124          | T 182/159 | tape eject    |
| 124113        | 1   | 124          |           |               |
| 124114        | 1   | 124          |           |               |
| 124696        | 70  | 124          | 159       | SQTP error    |
| 124697        | 93  | 124          |           | SQTP error    |
| 124932        | 1   | 124          | 184       | tape eject    |
| 124983        | 1   | 124          |           |               |
| 124934        | 1   | 124          |           |               |
| 124935        | 1   | 124          |           |               |
| 124936        | 1   | 124          |           |               |
| 125053        | 1   | 124          | 184       | tape eject    |
| 125054        | 1   | 124          |           |               |
| 125055        | 1   | 124          |           |               |
| 125056        | 1   | 124          |           |               |
| 125875        | 105 | 124          | 161       | SQTP error    |
| 126432        | 1   | 124          | 186       | bad shot      |
| 126986        | 1   | 124          | 186       |               |
| 127164        | 1   | 124          | 163       | bad shot      |
| 127738        | 1   | 124          | T 169/188 | reset system  |
| 127739        | 1   | 124          |           |               |
| 127740        | 1   | 124          |           |               |
| 127741        | 1   | 124          |           |               |
| 127742        | 1   | 124          |           |               |
| 127743        | 1   | 124          |           |               |
| 127744        | 1   | 124          |           |               |
| 127745        | 1   | 124          |           |               |
| 127746        | 1   | 124          |           |               |
| 127747        | 1   | 124          |           |               |
| 127748-127799 |     | reset system |           |               |
| 127800        | 1   | 124          |           |               |
| 127801        | 1   | 124          |           |               |



|               |     |              |           |               |
|---------------|-----|--------------|-----------|---------------|
| 127802        | 1   | 124          |           |               |
| 127803        | 1   | 124          |           |               |
| 127804        | 1   | 124          |           |               |
| 127805        | 1   | 124          |           |               |
| 127806        | 1   | 124          |           |               |
| 127807        | 1   | 124          |           |               |
| 127808        | 1   | 124          |           |               |
| 127809        | 1   | 124          |           | reset system  |
| 128104        | 65  | 124          | 188       | SQTP error    |
| 128181        | 103 | 124          | 188       | SQTP error    |
| 130805        | 1   | 124          | Abort 192 | reset system  |
| 130806        | 1   | 124          |           |               |
| 130807        | 1   | 124          |           |               |
| 130808        | 1   | 124          |           |               |
| 130809        | 1   | 124          |           |               |
| 130810        | 1   | 124          |           |               |
| 130811        | 1   | 124          |           |               |
| 130812        | 1   | 124          |           |               |
| 130813        | 1   | 124          |           |               |
| 130814        | 1   | 124          |           |               |
| 130815-131020 |     | reset system |           |               |
| 131021        | 1   | 124          |           |               |
| 131022        | 1   | 124          |           |               |
| 131023        | 1   | 124          |           |               |
| 131024        | 1   | 124          |           |               |
| 131025        | 1   | 124          |           |               |
| 131026        | 1   | 124          |           |               |
| 131027        | 1   | 124          |           |               |
| 131028        | 1   | 124          |           |               |
| 131029        | 1   | 124          |           |               |
| 131030        | 1   | 124          |           | reset system  |
| 132317        | 1   | 124          | 169       | tape eject    |
| 132318        | 1   | 124          |           |               |
| 132319        | 1   | 124          |           |               |
| 132774        | 1   | 124          | 194       | acquisition E |
| 134658        | 1   | 124          | 196       | bad shot      |
| 134830        | 1   | 124          | 173       | bad shot      |
| 134831        | 1   | 124          |           | bad shot      |
| 134867        | 1   | 124          | 173       |               |
| 135092        | 1   | 124          | 173       |               |
| 136003        | 1   | 124          | 198       | tape eject    |
| 136004        | 1   | 124          |           |               |
| 136005        | 1   | 124          |           |               |
| 136006        | 1   | 124          |           |               |
| 136263        | 1   | 124          | 175       | acquisition E |
| 136358        | 1   | 124          | 175       | tape eject    |
| 136359        | 1   | 124          |           |               |
| 136360        | 1   | 124          |           |               |
| 136361        | 1   | 124          |           |               |
| 136405        | 64  | 124          | 175       | SQTP error    |



|        |     |     |           |               |
|--------|-----|-----|-----------|---------------|
| 137414 | 1   | 124 | 200       | tape eject    |
| 137415 | 1   | 124 |           |               |
| 137416 | 1   | 124 |           |               |
| 137417 | 1   | 124 |           |               |
| 137859 | 66  | 124 | 177       | SQTP error    |
| 140107 | 1   | 124 | 156       |               |
| 140415 | 1   | 124 | T 156/181 | bad shot      |
| 140696 | 1   | 124 | 181       | tape eject    |
| 140696 | 1   | 124 |           |               |
| 140697 | 1   | 124 |           |               |
| 140698 | 1   | 124 |           |               |
| 141985 | 1   | 124 | 183       | tape eject    |
| 141986 | 1   | 124 |           |               |
| 141987 | 1   | 124 |           |               |
| 141988 | 1   | 124 |           |               |
| 142222 | 1   | 124 | 183       | tape eject    |
| 142223 | 1   | 124 |           |               |
| 142224 | 1   | 124 |           |               |
| 142225 | 1   | 124 |           |               |
| 143394 | 115 | 124 | 185       | SQTP error    |
| 143394 | 1   | 124 | 162       | tape eject    |
| 144332 | 1   | 124 |           |               |
| 144393 | 1   | 124 |           |               |
| 144567 | 1   | 124 |           | tape eject    |
| 144568 | 1   | 124 |           |               |
| 144569 | 1   | 124 |           |               |
| 144570 | 1   | 124 |           |               |
| 144854 | 37  | 124 | T 162/187 | SQTP error    |
| 146175 | 1   | 124 | 164       | acquisition E |
| 147666 | 1   | 124 | T 170/191 | error         |
| 148672 | 1   | 124 | 172       | acquisition E |
| 149501 | 1   | 124 | 193       | tape eject    |
| 149502 | 1   | 124 |           |               |
| 149503 | 1   | 124 |           |               |
| 149504 | 1   | 124 |           |               |
| 150025 | 1   | 124 | 174       | bad shot      |
| 150089 | 1   | 124 | 174       | tape eject    |
| 150090 | 1   | 124 |           |               |
| 150091 | 1   | 124 |           |               |
| 150092 | 1   | 124 |           |               |
| 150522 | 1   | 124 | 174       | lost shot     |
| 150561 | 1   | 124 | T 174/195 | lost shot     |
| 150732 | 1   | 124 | 195       | bad shot      |
| 150782 | 1   | 124 | 195       | bad shot      |
| 150888 | 104 | 124 | 195       | SQTP error    |
| 150890 | 78  | 124 | 195       | SQTP error    |
| 150892 | 119 | 124 | 195       | SQTP error    |
| 150894 | 114 | 124 | 195       | SQTP error    |
| 150895 | 50  | 124 |           | SQTP error    |
| 150896 | 78  | 124 |           | SQTP error    |



|        |     |     |             |               |
|--------|-----|-----|-------------|---------------|
| 150897 | 57  | 124 |             | SQTP error    |
| 150898 | 57  | 124 |             | SQTP error    |
| 150899 | 77  | 124 |             | SQTP error    |
| 150900 | 79  | 124 |             | SQTP error    |
| 150901 | 58  | 124 |             | SQTP error    |
| 150902 | 59  | 124 |             | SQTP error    |
| 150903 | 75  | 124 |             | SQTP error    |
| 150904 | 56  | 124 |             | SQTP error    |
| 150905 | 55  | 124 |             | SQTP error    |
| 150906 | 57  | 124 |             | SQTP error    |
| 150907 | 56  | 124 |             | SQTP error    |
| 150908 | 55  | 124 |             | SQTP error    |
| 150909 | 56  | 124 |             | SQTP error    |
| 150910 | 56  | 124 |             | SQTP error    |
| 150911 | 76  | 124 |             | SQTP error    |
| 150912 | 54  | 124 |             | SQTP error    |
| 150913 | 55  | 124 |             | SQTP error    |
| 150914 | 55  | 124 |             | SQTP error    |
| 151032 | 1   | 124 | 195         | tape eject    |
| 151033 | 1   | 124 |             |               |
| 151034 | 1   | 124 |             |               |
| 151035 | 1   | 124 |             |               |
| 151042 | 7   | 124 | 195         | missing shot  |
| 151104 | 1   | 124 | 195         | missing shot  |
| 151329 | 1   | 124 | T 195/176   | lost shot     |
| 151381 | 107 | 124 | 176         | SQTP error    |
| 151382 | 1   | 124 |             | tape eject    |
| 151383 | 1   | 124 |             |               |
| 151384 | 1   | 124 |             |               |
| 151385 | 1   | 124 |             |               |
| 151386 | 1   | 124 |             |               |
| 151387 | 1   | 124 |             |               |
| 151746 | 89  | 106 | 176         | SQTP error    |
| 151752 | 62  | 80  | 176         | SQTP error    |
| 151755 | 56  | 124 |             | SQTP error    |
| 156083 | 1   | 124 | 2-130       | bad shot      |
| 156210 | 4   | 124 | 2-130       |               |
| 156277 | 1   | 124 |             | acquisition E |
| 157241 | 1   | 124 | T2-130/2-96 | tape eject    |
| 157242 | 1   | 124 |             |               |
| 157243 | 1   | 124 |             |               |
| 157244 | 1   | 124 |             |               |
| 157595 | 1   | 124 | 2-071       | tape eject    |
| 157596 | 1   | 124 |             |               |
| 157597 | 1   | 124 |             |               |
| 157598 | 1   | 124 |             |               |
| 158583 | 1   | 124 | 2-027       | acquisition E |
| 160050 | 1   | 124 | THE END     | bad shot      |



## Appendix 16

### SCAM-24 Lcheapo

*SCripps - CAMbridge 24 bit Analog(ue) to Digital Sub-System for Lcheapo.*

Tim Owen & Paul Zimmer—Oct. 19th 1997.

This report describes the 24 bit signal interface developed by us for the Lcheapo Ocean Bottom Instrument aboard R/V Ewing on cruise 97-07. It describes the design and software modifications made and proposed, and the limitations of the completed system. Hints on the layout of a final printed circuit board are included as it was not possible to reach this stage on board ship. The A to D converter chip set used is the same as that in the Cambridge miniDOBS system, and the operating protocol follows a similar system. We developed a simpler interface than the miniDOBS one for the Lcheapo to reduce power consumption and simplify construction.

**ADC description:** The SCAM-24 interface uses the Crystal CS5322/CS5321 converter chipset. This consists of a CS5321 4th order 1 bit delta sigma converter running at 250 or 125khz and a CS5322 DSP chip with programmable decimation rate giving 24 bit outputs at rates from 31.25 Hz to 4000Hz in binary steps. The DSP chip implements a multi-stage digital anti-alias filter with a final stage of 29 coefficients giving a cut-off starting at 70% of Nyquist, and reaching -110 dB at the Nyquist frequency. A single RC filter on the input is adequate to avoid aliasing at the 1 bit sampling rate. The FIR filter results in a time delay of 29 samples between input and output. The chipset thus provides all the elements necessary for the analogue signal path, except for any input pre-amplifier for impedance matching. The ADC chipset needs a high frequency clock (512khz or 1024khz ) to derive its 1 bit sampling rate and its output rate. The MC68332 processor in the Tattletale TT8 used as the basis for the Lcheapo (& in the Cambridge miniDOBS) has an autonomous queued serial interface - the QSPI port - which is ideal for communication with the ADC DSP chip, and its address lines allow control of channel select for 4 channels and one other function (R/W). Our design retained the IRQ4 data ready interrupt, and the basic program structure, replacing a couple of modules and modifying the foreground system slightly.

**Operation of CS5321/CS5322:** The chipset communicates with the Lcheapo via the QSPI port operating in MASTER mode - i.e. transfers are initiated by the CPU. The CS5322 is set up either by executing a reset, then writing a 16 bit status word with the appropriate combination of RSEL and R/W with the appropriate sampling rate set, or a reset with the hardware option links appropriately set (the link H/S selects between hardware and software set-up modes). The CS5322 chip has the option of software set-up, or set-up via hardware inputs - on the prototype we opted for the hardware set-up option using links. The ADC does not start running until a SYNC pulse is received by the CS5322, this is derived by gating a system 1 second pulse to the RESET pin. N.B. Repeated SYNC pulses cannot be used unless they are EXACTLY synchronised with the ADC clock. When running, the Interrupt is enabled, and on receipt of the interrupt request, the routine CVHandler() calls ADSample() to read. ADSample sets the appropriate addresses and command codes etc. in the QSPI registers and initiates a transfer that then clocks the 24 bit data from the CS5322 to the QSPI receive memory. In a multichannel system all channels can be scanned in a single QSPI operation. The Interrupt flip-flop is set by the CS5322 -DRDY line and reset when R/W is set high to begin a read.



**Clock System:** The Lcheapo uses a SeaScan software compensated clock module for timekeeping. This works by using a microprocessor to adjust the output of an uncompensated but high quality crystal according to a correction table derived from measurements of rate against temperature. The processor clocks out a 125 Hz waveform derived by counting down input 12.5 KHz (or near) clocks from raw crystal, and increasing or decreasing the countdown coefficient by one whenever a correction is need to compensate for temperature according to the table. The net effect of this technique is that the clock edge jumps periodically by 1 input pulse - 8 usecs -from its regular position, an effective instantaneous frequency shift of 0.1%. Since all frequencies within the Lcheapo are derived from the 125Hz source by phase locked loop, it follows that they must all be subject to periodic perturbations. The extent of any resulting clock jitter and noise will depend critically on the design of the phase locked loop used for frequency multiplication, but since the design of phase locked loops is a difficult compromise, imperfections are inevitable. The CS5321 chip generates less self noise due to clock jitter than the earlier CS5323 chip, but any ADC system will inevitably generate signal related noise if the sampling clock is noisy - digitisation time jitter equating to amplitude jitter in the presence of a signal. The extent of this noise in the present design is simply a function of the phase locked loop performance, but it will be impossible with the present clock arrangement to remove it completely. Identical limitations apply to any sampling ADC.

**Phase Locked Loop Design:** The normal system uses a phase detector comparing the input waveform and the counted down output waveform to generate a phase difference signal which is filtered and used to control the Voltage Controlled Oscillator - VCO - that generates the output frequency. Loop stability and damping criteria impose severe limitations on the performance of the system, it is very difficult to integrate the phase signal to the VCO sufficiently to avoid glitches on the frequency output while still maintaining an adequate phase margin at the 0dB loop gain point (i.e. to keep the point (1,0) outside the envelope of the Bode diagram). To do this while producing a very large step-up factor and achieving a low power figure is tricky. The design incorporated uses a 74HC4046 chip and has been partially optimised, it has a current consumption of about 3.5mA at 5V - there are probably better chips available! The figures attached show a plot of the signal related noise for a good ADC clock input against the PLL with the SeaScan input, and a plot of the difference between in signal generated noise when the PLL runs with the SeaScan clock or a good 125Hz source.

**System Software:** We wrote a new version of ADSample for 24 bit recording. We propose a new dynamic compression system based on embedded reserved codes - essentially banning a couple of data values at the top and bottom of the full scale, and using these values (e.g. 0x800000, 0x7FFFFFF in 24 bit form) to flag changes in the representation. The Compress software would look at the bit length of the 1st difference, and represent the data as either 24 bit direct data, or 16 or 8 bit 1st difference data. It could equally well operate for direct rather than 1st difference data. A draft set of codes is described below. The only other changes we made to the existing code were to remove elements relating to the ADC gain control and recording of the old system, and to change the size of a couple of variables (samp\_ptr in Global to char \* and da in CVHandler to long \*). We provided a utility LC24.C, to translate files from the instrument from 24 bit mode to text files for input into MATLAB. We did not define any new recording modes or set any flags in the data headers to indicate the new recording mode, as the code was a little difficult to follow in this area.

**Performance:** The original development was done with a lash-up using a Cambridge miniDOBS ADC board which is a 4 layer board with very careful arrangements of analogue and digital power and ground, and this gave a very good noise figure - about 7 counts of noise. The prototype SCAM-24 board for inclusion in the Lcheapo rack was noisier,



although careful modifications reduced the self noise to acceptable limits. Measurement of signal related noise showed the dependence of this variable on phase lock loop design. It is difficult to measure the final system performance precisely, given the very high resolution of the ADC system and the unknown imperfections in the test gear. The signal related noise test data below shows a rise of up to 12 dB in the flanks of the signal peak due to the PLL. In practice for seismic signals there are unlikely to be serious problems, but it should be considered carefully for new applications, and if any changes are proposed to the clock system. The test plots of self noise show little difference between the two clock systems. The sharp cut-off of the digital filter is clearly seen, as is the wide dynamic range of the system (the input 20 Hz wave was 5 dB below the clip level). Our final prototype came very close to the Crystal specifications for the chip.

**Power Consumption:** A key issue in initial discussions concerning choice of ADC chip was power consumption, and for this reason Scripps initially favoured the Harris HA7190 chip - however a full study highlighted serious problems with the anti-alias digital filter of the Harris that would have necessitated retaining the switched mode analogue filters and left the power balance only slightly against the CS5321/CS5322 set. Given the other limitations of actual resolution of the Harris, which is clearly meant for intermittent rather than time series measurement, the Crystal set was chosen. The chip current per channel for the CS5322/CS5321 set is 3 mA from the +5V analog(ue) line and 3 mA from the -5V analog(ue) line plus 2.2mA from the +5V digital line in low power mode (perfectly adequate for the sampling rates needed) - a minimum figure of 42.5mW. The Phase Locked Loop and associated chips account for another 17.5 mW. A four channel ADC subsystem thus consumes about 170 mW + PLL = 187.5mW. In our single channel SCAM-24 prototype implemented with a fairly carefully designed phase locked loop, we achieved a reduction in the overall power consumption of the Lcheapo from 325mW to 195mW, possibly due to the CPU spending less time at high clock speed or better PLL design? Changing hydrophone will save around 34mW, of which 17mW is a system cost on the +ve Analogue supply and the rest free in the present arrangement. Getting rid of the -ve battery pack (only possible if the hydrophone is changed) and using an inverter for the analogue -5V supply would compensate for the increased drain of the Crystal chipsets in a 4 channel instrument! The Cambridge miniDOBS generates the -ve analogue voltage from the +5 supply using a MAX660 switched capacitor inverter running in synchronisation with the ADC clock to reduce beat interference. Sufficient -5V output is available on the miniDOBS for pre-amplifiers. Careful selection of the +5 voltage regulators for the ADC supply would allow the input voltage to run down to about 5.6V if a separate ADC battery were used. It is possible that the +5V ADC supply could be generated by a switched mode supply from the main battery pack, thus further reducing consumption, but this would require careful design of circuit and board - Crystal recommend that in such cases the switching frequency is derived from the ADC clock to avoid beat noise.

Projecting figures for the power consumption of a four channel SCAM-24 based instrument highlights the very high power cost of the disk. The Cambridge miniDOBS use a virtually identical Hard Drive and a (presumably) similar SCSI interface chip running from an identical processor at a 20% lower CPU clock speed. It achieves data dumps of 2 Mbytes (single channel instruments) in 20 secs spin up plus about 4 secs write time, and dumps 4 Mbyte of data (four channel instruments) in a 20 secs spin up plus about 16 secs of write as against an Lcheapo disk on time for a 2mbyte dump time of 56 seconds. The net effect is that the Lcheapo disk system runs for 112 secs, including two (high powered) spin ups for what the miniDOBS does in 36 seconds - a factor of at least 4 less. Lcheapo would have almost double the deployment life if similarly efficient.

**Four Channel Instrument:** All the basic development work has taken account of the need to expand to a four channel SCAM-24 system. To do this 4 CS5322/CS5321



chipsets must be accommodated on the board, plus a 1 of 4 decoder chip for the chip selects - a 4 input & gate could be used to generate an ORed function of -DRDY, but a single one is probably adequate as all chips should run exactly in synchronisation. The QSPI port will address and load 4 status words to the ADC, and will read 4 data words in a single operation, so software changes are minimal. The power consumption of the system will rise by the extra power for the ADC chips, and possibly a little for the additional time the CPU is running at a higher clock speed. Give that the 24 bit system does not need any gain management, software should simplify significantly, and the system may well run with the same or longer low powered sleep periods, thus save power.

**Circuit Layout:** The prototype SCAM-24 board we made does not follow a recommended layout in that the analogue section is too near the CS5322 digital chip and serial connections between CS5322 & CS5321 are long. The circuit needs to be implemented as a 4 layer board with separate ground planes for analogue and digital circuitry, and a rigorous common earth point strategy - see Crystal data book for some hints. All digital chips need to be decoupled directly across the power pins, and general good practice followed. There should be adequate room on the board for four CS5322/CS5321 chipset and select decoder, the Phase Locked Loop and associated logic, and necessary voltage regulators & inverters. If using the existing hydrophone, the 402 Ohm resistor and a decoupling capacitor from the -ve battery supply should be placed near the ADC input. With an unamplified hydrophone, the high impedance input pre-amplifier should be mounted in a screened box round the back of the input connector, and screened 4 core cable run to the ADC board (+5, -5, Gnd & signal).

**Hydrophone:** The Lcheapo uses a proprietary hydrophone HTI-90-U-055 that uses a high input impedance transconductance amplifier to modulate the output signal upon the supply current, whence it is recovered by a resistor and a hi pass filter. I guess that the hydrophone itself consists of two ceramic cylinders of PZT5 lead zirconium titanate material of size about 25 mm OD and 3 mm wall thickness, in two sections that are wired in parallel for the low frequency version used (double the capacitance, half the output voltage). The cylinder is used in air backed mode with the pre-amplifier in the void, this mode doubles the sensitivity, but probably at the expense of increased pressure dependence of sensitivity as compared with the solid potted configuration. The raw capacitance of the elements must be around 10 nF, so that the effective input resistance for the stated frequency response must be of order about 200 Mohms ( $f = .05$ ,  $C = 10\text{nF}$ ,  $R = 2\pi f C$ ) if the element is working in voltage mode. The quoted performance of the hydrophone with a 402 ohm load is a sensitivity of -185 dB re: 1V/uPa, and a self noise of 46dB re 1uPa/root Hz at 10Hz. This corresponds roughly to an RMS noise of around 1 or 2 microvolts across the 1 to 100 Hz band. The figures given by HTI for state 0 sea noise output is some 30 dB higher than this at 10 Hz, say around 50 uvolts RMS in the band 1 to 100 Hz. The HTI hydrophone claims to have a clip level of 170 dB re 1 uPa, equivalent to an output level of +/- 4.2 volts. Since the standing current in the 402 Ohm load resistor is only 2.7 mA, the DC voltage across the resistor is approximately 1 volt, and the output is therefore limited to a 1 volt negative excursion (unless the circuitry is more clever than I would guess!) The clip level must therefore be at most +/- 1 Volt or 185dB ref 1 uPa. The ratio between the stated self noise level and the Johnson noise in the inferred input resistor would imply an internal voltage attenuation of order 10, which would be reasonably consistent with a full scale element voltage swing of almost 10 volts and a full scale output voltage swing of +/- 1 V.

Given the ADC has a 24 bit resolution and a full scale range of +/- 4.5 Volts, one digitisation interval is .536 microvolts. With the prototype system a peak to peak noise level of around 16 counts was achieved with shorted input, giving an approximate input RMS noise level of less than 5 microvolts from 1 to 100 Hz. An improved input noise



figure should result from the use of a 4 layer PCB and careful layout of components and screening, but it is very unlikely to be less than the self noise voltage of the hydrophone, although well below the deep sea base noise level. Given the mis-match between the inferred clip level of the hydrophone and the input range of the ADC, it is sensible to use the Hydrophone with an amplifier with a gain of 4.5 to preserve the full sensor dynamic range.

We recommend that the Hydrophone manufacturer be asked to check and confirm the specifications, particularly clip level, to ensure a proper match.

**N.B.** It is worth noting that the performance of a hydrophone is only the sum of the performance of the ceramic element (which is an item of commerce) and the pre-amplifier, and the construction techniques have no practical effect upon electrical performance. The raw elements have quite tight tolerances within a batch, so hydrophones made from similar elements will show little variation in sensitivity - probably only a few percent. Accurately testing the sensitivity of a hydrophone is a very tricky - I doubt most manufactures get any closer than the spread of element tolerances - I'm equally sure that none calibrate elements before encapsulation, and never have to discard any due to variations in element properties. It is relatively easy to design and build hydrophones at a considerable cost saving, and if an external pre-amplifier is used, an increase in versatility, and a saving of power ( 32 mWatts for the HTI-90-U-055). Dispensing with the HDI hydrophone would mean that the -5V ADC supply could be derived from the +5 supply as in the miniDOBS instead of a separate battery pack, and only a single pack of 7 to 8 volts would be needed at a considerable saving in overall power budget. The hydrophone pre-amplifier could be run from the ADC +/-5V supplies.

**Conclusions:** We have developed the SCAM-24 ADC sub system for the Lcheapo instrument that can be implemented in single channel form at a considerable power SAVING. The subsystem is much easier to build and test, since there is no need for elaborate anti-alias filters, and the system performance is guaranteed by the chip design. Sampling frequencies can be changed across the full range without any hardware modifications. The CS5322/CS5321 chipset is expensive (order of \$250?), but given the savings in complexity, it represents, if anything, a saving when full purchase and construction costs are considered. The prototype software we developed did not include compression, although we did design an algorithm and produce a draft specification- see below. It offers a much more versatile method of compression flagging for a 24 bit system than the existing Lcheapo mode method. (Please consult Tim Owen for further details and implementation of this system). A four channel version has been included in our design suggestions, and is a straightforward extension of the prototype - the power budget highlights the relatively low cost of the 24 bit, four channel sub-system in terms of the other system costs. Extension to more than 4 channels should require only minor modifications.

Three areas suggest themselves for further work to improve the system performance and reduce power consumption :

- 1     *Implement the suggested compression algorithm.*
- 2     *Investigate using a passive hydrophone and pre-amplifier to simplify the power supplies and possibly reduce costs.*
- 3     *Investigate the transfer speeds for the SCSI interface to reduce disk run time.*



Overall, the SCAM-24 design presented represents a significant enhancement to the performance of Lcheapo, offering the potential for an instrument in a single long tube recording for over a year in single channel mode at 256 samples per second, or in four channel mode at 31.25 samples per second (subject to the availability of disks of adequate capacity - order 30 GBytes). Measured performance came very close to the specifications for the Crystal chipset used.

A record section from the 2-airgun test deployment is shown on the following page (*Figure* Sir Charles Barkley 24-bit A/D L-Cheapo).

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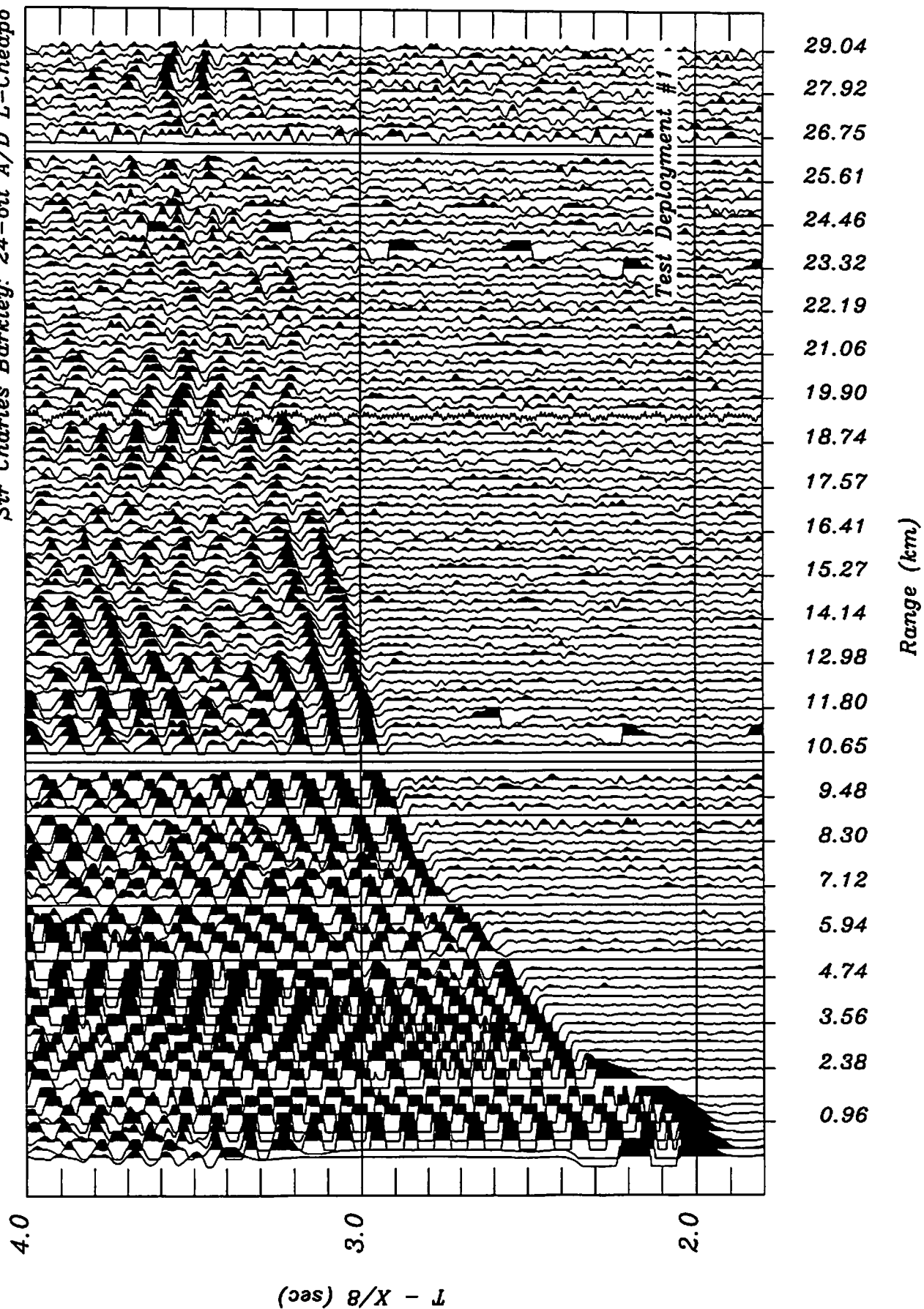
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Sir Charles Barkley: 24-bit A/D L-Cheapo





## Appendix 17

### Future 3-D Checklist

- DGPS coverage: Inmarsat-based corrections require line-of-sight to satellite; current Inmarsat receiver aboard Ewing maybe be blocked by radar platform (for certain locations and line azimuths). Best to have current or similar system moved onto radar platform. For some surveys, new P-code receiver may not be accurate enough—better check first!
- Navigation Resampling: Check status of current program aboard Ewing to resample and smooth DGPS data; problems may arise (see Navigation section) which can cause a 10-30 m offset (twice the error across adjacent bins), which could be very serious if not corrected.
- Compass Bearing: Some *Digicourse* 'birds were found to have a degree or two bias in measured bearing; this should be apparent by comparing adjacent lines shot in opposing directions. Best to remove bias.
- 'Bird Collar: Over-screwing of the collar nut may crack the collar unit ('birds are attached to these collars in two places), which could result in loss of 'bird and bearing measurements, if crack results in failure.
- Realtime compass measurements: Make sure that there is no delay between shot and compass reading; original scheme resulted in a 1 or 2 shot delay between location and compass bearing.
- Tail Buoy: At present, *Garmin* receiver/transceiver on PGS tail buoy is 2 Watts, not the 30 Watt version—2 W unit can not transmit more than a few 100 meters. Replace ASAP! Also handy to bring hand held version which can be used via work boat/rescue boat to verify bearing solution.
- Gun Failure: Guns may experience problems after 100,000 shots, give or take. Maybe best to rebuild guns along the way, instead of waiting for failure mode.
- Biological Growth: During long deployments, barnacles may sprout on your streamer, may be best to pull in the first few sections every week or so, and evaluate.
- OBH/Ss: For dense arrays, try a work boat recovery scheme if seas are calm, or nearly so! Can save quite a bit of time.
- Have a wonderful "zamboni" or two! !:>)



