LARSE.1 MCS

MULTICHANNEL SEISMIC-REFLECTION PROFILING ON THE R/V MAURICE EWING DURING THE LOS ANGELES REGION SEISMIC EXPERIMENT (LARSE), CALIFORNIA

Thomas M. Brocher[1], Robert W. Clayton[2], Kim D. Klitgord[3], Robert G. Bohannon[3], Ray Sliter[3], John K. McRaney[4], James V. Gardner[3], and J. B. Keene[5]

[1] 345 Middlefield Road, M/S 977, Menlo Park, CA 94025
[2] Caltech, Seismological Laboratory, Pasadena, CA 91125
[3] 345 Middlefield Road, M/S 999, Menlo Park, CA 94025
[4] Dept. Geological Sciences, University of Southern California, Los Angeles, CA 90089-0740
[5] Dept. Geology and Geophysics, The University of Sydney, N.S.W. 2006, Australia

Data Set 02-006

USGS Open-File Report 95-228

Distributed by

Incorporated Research Institutions for Seismology
Data Management Center
1408 NE 45th Street, Suite 201
Seattle, Washington 98105
www.iris.washington.edu

 USGS-OFR-95-228

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MULTICHANNEL SEISMIC-REFLECTION PROFILING ON THE R/V MAURICE EWING DURING THE LOS ANGELES REGION SEISMIC EXPERIMENT (LARSE), CALIFORNIA

By

Thomas M. Brocher[1], Robert W. Clayton[2], Kim D. Klitgord[3], Robert G. Bohannon[3], Ray Sliter[3], John K. McRaney[4], James V. Gardner[3], and J. B. Keene[5]

Open-File Report 95-228

[1]345 Middlefield Road, M/S 977, Menlo Park, CA 94025
[2]Caltech, Seismological Laboratory, Pasadena, CA 91125
[3]345 Middlefield Road, M/S 999, Menlo Park, CA 94025
[4]Dept. Geological Sciences, University of Southern California, Los Angeles, CA 90089-0740
[5]Dept. Geology and Geophysics, The University of Sydney, N.S.W. 2006, Australia

Menlo Park, California
1995

ABSTRACT

This report describes the acquisition of deep-crustal multichannel seismic-reflection data in the Inner California Borderland aboard the R/V **Maurice Ewing**, conducted in October 1994 as part of the Los Angeles Regional Seismic Experiment (LARSE). LARSE is a cooperative study of the crustal structure of southern California involving earth scientists from the U.S. Geological Survey, Caltech, the University of Southern California, the University of California Los Angeles, and the Southern Califomia Earthquake Center (SCEC). During LARSE, the R/V **Ewing's** 20-element air gun array, totaling 137.7 liters (8470 cu. in.), was used as the primary seismic source for wide-angle recording along three main onshore-offshore lines centered on the Los Angeles basin and the epicenters of the 1933 Long Beach and 1994 Northridge earthquakes. The LARSE onshore-offshore lines were each 200-250 km long, with the offshore portions being between 90 and 150 km long. The nearly 24,000 air gun signals generated by the **Ewing** were recorded by an array of 170 PASSCAL REFTEK recorders deployed at 2 km intervals along all three of the onshore lines and 9 ocean bottom seismometers (OBSs) deployed along two of the lines. Separate passes over the OBS-deployment lines were performed with a long air gun repetition rate (60 and 90 seconds) to minimize acoustic-wave interference from previous shots in the OBS data. The **Ewing's** 4.2-km, 160-channel, digital streamer was also used to record approximately 1250 km of 40-fold multichannel seismic-reflection data. To enhance the fold of the wide-angle data recorded onshore, mitigating against cultural and wind noise in the Los Angeles basin, the entire ship track was repeated at least once resulting in fewer than about 660 km of unique trackline coverage in the Inner Borderland. Portions of the seismic-reflection lines were repeated up to 6 times. A variety of other geophysical data were also continuously recorded, including 3.5 kHz bathymetry, multi-beam swath Hydrosweep bathymetry, magnetics, and gravity data. In this report, we describe the equipment and procedures used to acquire multichannel seismic-reflection and other geophysical data aboard the **Ewing,** provide a detailed cruise narrative, discuss the reduction of the data, and present near-trace constant offset seismic sections of the acquired profiles.

CONTENTS

FIGURES

TABLES

INTRODUCTION

The seismic earthquake hazards posed by blind thrust faults in southern California have been reported by a number of investigators [Stein and King, 1984; Stein and Yeats, 1989; Wright, 1991; Crouch and Suppe, 1993; Davis and Namson, 1994; Shaw and Suppe, 1994; Shaw et al., 1994]. Seismic-reflection methods are a valuable and necessary means of imaging the folding associated with blind thrusts, and have provided constraints for balanced cross sections used to map thrust ramps in the subsurface. Both the damaging 1971 San Fernando and 1994 Northridge earthquakes occurred on a blind thrusts [U.S. Geological Survey and the Southern California Earthquake Center, 1994].

This report describes shipboard operations on the R/V **Maurice Ewing**, leg EW-9415, including the acquisition of deep-crustal multichannel seismic-reflection data as part of the Los Angeles Regional Seismic Experiment (LARSE). LARSE is a cooperative study of the crustal structure of southern California involving scientists from the U.S. Geological Survey (USGS), Caltech, the University of Southern California, the University of California Los Angeles, and the Southern California Earthquake Center (SCEC). Seismic-reflection profiling in the greater Los Angeles area, 13-21 October, 1994, used the **Ewing's** 8470 cu. in. (137.7 liter) air gun array and 160-channel, 4.2-km digital streamer. The **Ewing's** air gun source was also recorded by 170 temporary land recorders (REFTEKs), the permanent southern California earthquake net, an array of 9 ocean-bottom seismometers deployed along two lines, and two successful sonobuoys. The **Ewing** fired nearly 24,000 air gun shots during the LARSE work. The **Ewing**, a 239' (72.8 m) long UNOLS vessel, formerly an industry seismic-reflection vessel, is operated by the Lamont-Doherty Earth Observatory.

The R/V **Ewing** acquired several deep-crustal seismic-reflection profiles on the continental shelf of the Inner California Borderland, in the vicinity of Los Angeles, stretching from the $32^{o}38'$N to 34^{o}N and from $119^{o}45'$W to $117^{o}40'$W (Figure 1a). At the heart of LARSE was the collection of three long onshore-offshore lines, Lines 1 to 3, which provided air gun signals for land recorders deployed along the projections of these lines. These lines include: (1) Line 1 trending N-S from the center of San Clemente Island through Seal Beach projecting into the 1933 Long Beach earthquake epicenter and the Mojave Desert, (2) Line 2 trending N-S along the western shores of San Clemente and Catalina Islands through Santa Monica projecting through the 1994 Northridge earthquake epicenter, and (3) Line 3 trending NE-SW from northwest of San Nicolas Island through the center of Los Angeles basin [Wright, 1991]. These three lines provide a regional reconnaissance of the crustal structure centered on the Los Angeles Basin: in addition they provide specific information about the crustal structure in the vicinity of two recent, damaging earthquakes in the greater Los Angeles region. Special care was taken to acquire large segments of these lines late at night (2300 L to 0500 L) [all local times given herein are Pacific Standard Time, which is 7 hours behind UTC], causing us to repeat parts of Lines 1 and 2 up to 5 times (Figures 2a and 2b). The planned ship track was altered throughout the cruise in order to maximize the acquisition of onshore-offshore data during late-night hours. Ocean bottom seismometers (OBS's) were deployed only along LARSE Lines 1 and 2.

Shorter transit reflection lines, TR1, TR2, and TR3, connected LARSE Lines 1, 2 and 3 (sees Figure 1a and 1b). These transit lines were recorded in an oblique, fan geometry by the temporary and permanent onshore seismic stations. LARSE Line 3 was acquired between Lines 1 and 2 to provide enough time for the array of nine ocean bottom seismometers (OBSs) to be retrieved from along Line 1 and redeployed along Line 2 (Appendix 1). Upon completion of Line 2, the **Ewing** acquired reflection data along Line TR3 and then repeated the southern half of Line 1. The **Ewing** then acquired a series of short lines (Lines 4 and 6) crossing the Palos Verde and Newport-Inglewood faults while heading southeasterly towards San Diego, California (Appendix 1). Pre-cruise plans to shoot multichannel seismic (MCS) reflection lines in Santa Barbara Channel were abandoned because of the need to reshoot parts of Lines 1 and 2. No air gun shots were fired within the three-mile state limit for acoustic sources. Companion Open-file Reports describing the ocean-bottom seismometer and onshore recording of the LARSE air gun shots as well as the LARSE land refraction work using large chemical explosions are in preparation.

DATA ACQUISITION

Instrumentation on the **Ewing**

Multichannel seismic-reflection profiling on the **Ewing** was performed using a 20-element, 137.7 liter (8470 cu. in.) air gun array (Figure 3 and 4) and a 160-channel, 4.2-km-long digital Digicon streamer. The air gun array, composed of Bolt air guns, was generally towed at depths between 8 and 10 meters. As shown in Figure 2, 8 guns were towed on each side of the ship from large retractable booms that are swung out abeam of the ship. The remaining four air guns were deployed from an A-frame on the stern of the ship. The ship-to-gun distance is staggered to minimize fouling the air guns and to optimally separate the air bubbles created by the air gun array: the center of the air gun array was towed approximately 39.6 m behind the stern of the ship (Figure 3). The width of the air gun array across the beam of the ship was roughly 33.8 m (111 feet) (see Figure 4). The Magnavox Global Positioning Satellite (GPS) receiver for the ship was located above the ship's bridge about 47.8 m forward of the stern of the ship, 87.4 m forward of the center of the air gun array. The sizes of the air gun chambers varied from 145 cu. in. (2.4 liters) to 875 cu. in. (14.2 liters) to provide a tuned outgoing source wavelet (Figure 4). Calculations of the source wavelet for this air gun array give a peak-to-peak pressure of 136.4 bar-meters and a primary/bubble ratio of 7.6 (Figure 5).

Air gun shot times recorded in the navigation files were from the air gun fire command time determined from a Magnavox GPS clock. These shot times are considered accurate to within a millisecond. The air guns were generally fired during turns to permit the onshore recording of the air gun signals; air guns were shut off only when turning within the 3-mile state limit.

For MCS profiling we used a 4.2 km, 160-channel digital seismic streamer built by Digicon. The streamer's group interval was 25 m and digitizers were located every 100 m (4 groups) along the streamer. The digital streamer data were telemetered to the Digicon DMS-2000 recording system after every shot (Appendix 2). The streamer was deployed directly behind the ship from its reel with the center of the first active section of the streamer located 187.5 m behind the center of the air gun array, 227.5 m behind the stern of the ship, and 275.3 m behind the ship's GPS receiver on the bridge (Figure 3). The streamer, having 19 depth control fins (birds) and a large tail buoy, was generally towed at a depth of 10 to 12 meters, depending on the sea-state conditions. The birds were Model 5010 manufactured by Digicourse, and incorporate pressure sensors. The pressure sensors provided depths along the streamer to the main lab and electronics within the birds automatically adjusted the bird fin angle (deviation from horizontal) to maintain the selected streamer depth. The streamer was positively buoyant during the cruise and the tail of the streamer (including the last 3 to 4 birds) tended to tow at a depth less than 10 to 12 meters.

Appendix 2 describes the Digicon DMS-2000 recording system used to record the seismic-reflection data on the **Ewing**. We recorded 16-second record lengths with a 2-millisecond sample rate. At first the air gun array was triggered on distance every 50 meters along the tracklines. Because the record length plus 3 seconds (for system start-up overhead) cannot exceed the shotpoint interval with this recording system, we had to alter our air gun shooting schedule from distance to time (every 20 s) when strong currents caused an increase in ship's speed over the ground decreasing the shot time interval to less than 19 s. This change was made during Line 3 at 0353 UTC on JD 289.

The Digicon DMS-2000 system recorded MCS data in SEG-D format on dual 3480 cartridge tape drives [Barry et al., 1975; SEG Subcommittee on Field Tape Standards, 1994]. After writing a tape in about 20 minutes, MCS data logging automatically switched over to a second tape drive, and the completed cartridge tape and cartridge label were ejected from the drive. Navigation data as well as information about the status of the MCS system were written to separate NAVLOG 3480 cartridge tapes (Appendix 2). 450 cartridge tapes containing MCS data were written during leg EW94-15. ProMAX software running on a Sun SPARCstation reformatted the SEG-D tapes into SEG-Y format, transcribing the 3480 cartridge tapes onto 2-Gbyte Exabyte tape. An approximate 5:1 tape compression resulted in 80 Exabyte SEG-Y tapes (see Appendix 3). Appendix 3, which was largely completed at sea, also provides a list of shots that were not recorded by the DMS-2000 system and the 3480 cartridge tapes that could not be read by the ProMAX system onboard the **Ewing**. Under every Exabyte tape, Appendix 3 provides a table showing the 3480 cartridge tape numbers written to the Exabyte tape, the Field File Identification numbers (FFID), and the corresponding shot-point number for each FFID written to Exabyte tape. Appendix 3 is thus an inventory of the data stored on both the original SEG-D 3480 cartridge tapes and the SEG-Y Exabyte tape copies.

ProMAX seismic data processing software was used to monitor the recorded seismic-reflection data quality in near real-time. This software, installed on a Sun SPARCstation, was primarily used to visually inspect every 50th shot gather as well as to transcribe the SEG-D data from 3480 cartridges into SEG-Y format on Exabyte tape format. Limited segments of the lines were also plotted as a constant offset section to monitor data quality.

Acquisition of multichannel seismic-reflection data on the **Ewing** was controlled by several personal computers (PCs) that each monitored a different aspect of the acquisition system. For every shotpoint separate PCs provided a record of the error of the firing time for each air gun (errors less than 1 msec were specified), the air gun depth, the bird depth and fin angle, the streamer depth, signal levels on every fourth channel of the streamer, and the data-file number and shot number for every shot. Sun workstations were used to log other geophysical data (Appendix 2).

Navigation on the **Ewing** was based on redundant Magnavox GPS receivers operated in selected availability mode: the GPS locations were smoothed over a ten-minute window and updated using the Furuno course and speed log. This navigation was written to a separate 3480 cartridge tape and is estimated to be accurate to within 25 meters.

Files containing air gun origin times and final air gun locations were sent from the **Ewing** via e-mail to all LARSE investigators on a daily basis. These origin times were used to examine the quality of data recorded onshore by the three deployments of REFTEK arrays. The reduction and playback of wide-angle data during the field experiment were instrumental for the decision to repeat Line 1 to insure that this line was reshot during late-night hours. Communication with other LARSE personnel was by cellular phone.

Fifteen model 53B expendable military sonobuoys were launched during the cruise, almost entirely on Line 3. Only two sonobuoys functioned properly, however, these sonobuoys yielded useful records to distances as much as 30 km (Table 2). The successful buoys were dropped by hand from the end of the portside air gun boom. No successful buoys were launched from the sonobuoy launcher. The first successful buoy was launched on the outbound leg of Line 3. The second successful buoy was launched near the intersection of Lines 2 and 3, and was recorded during Lines 03R, TR2, and 02. All buoys were programmed to release their hydrophone to a depth of 90 feet and to broadcast for 8 hours before scuttling.

Several other kinds of data were continuously recorded on the **Ewing** including navigation, magnetics, gravity, 3.5 kHz bathymetry, Hydrosweep swath bathymetry, and sea-surface temperature data (see Appendix 4). The quality of the 3.5 kHz echo sounder data is considered to be excellent, and provides abundant evidence for recent faulting in the offshore (Figure 6). Magnetic-anomaly data were continuously recorded using a Varian V75 magnetometer towed behind the ship. Gravity data were acquired using KSS-30 and BGM-3 gravimeters (Appendix 4). Appendix 4 describes the format of the daily files created for each of the data types, and indicates when data were not acquired for each of the instruments. Appendix 5 describes how the digital Hydrosweep data can be plotted as maps of seafloor depth or seafloor reflectance.

Ewing Cruise Narrative

The **Ewing** left her berth at Long Beach Harbor at 1516 UTC on Julian Day (JD) 286 (0816 L on 13 October 1994). She then steamed to a location several miles southeast of the first way point at the northern end of Line 1 just south of the Long Beach harbor entrance. Upon reaching this way point the 8470 cu. in. air gun array was immediately deployed. Because of the heavy ship traffic at this location, the MCS streamer was not deployed on this first pass along Line 1.

The first pass of Line 1 (LA01) was designed only as a source for the OBS's and onshore recorder array. It was collected using a 60-second air gun repetition rate to minimize water-wave arrivals on the OBS records. LA01 commenced at 1830 UTC (1130L) and the ship was on course for Line 1 at 1849 UTC on JD 286 (1149 L on 13 October 1994). Without towing the streamer, the **Ewing** was able to start shooting the line northeast of the coastwise shipping lane and to transit between oil platforms in the separation zone of the shipping lane. The offshore portion of Line 1 runs about 84 km from the commercial anchorage south of Seal Beach to the three-mile limit off the center of San Clemente Island (Figure 2a).

After completing the first OBS pass of Line 1 at the three-mile limit of San Clemente Island, the ship turned easterly to deploy the streamer at approximately 0600 UTC on JD 287 (2300L of 13 October 1994). During the deployment of the streamer a number of sections were pumped with oil to properly ballast the streamer. We also changed one failed compass section in the new, front part of the streamer. The replacement compass section, however, also failed to work. Only the compass sections in the older part of the streamer near the tail, having digitizing cans, properly functioned during the cruise. As the streamer was deployed, the depth control fins (birds) were attached one by one and checked to insure they were functioning properly. The streamer was completely deployed by 1155 UTC on JD 287 (0455 L on 14 October 1994) and Line 01R was commenced (Fig. 1a). After transiting westward to the southernmost way point for Line 1 north of San Clemente Island, the **Ewing** completed an inside turn and MCS data acquisition on Line 1R northbound commenced at about 1600 UTC JD 287 (0900L on 14 October). Line 1R had to deviate northwest of the oil platforms and therefore the northeastern end of the line was not exactly along the Line 1 onshore-offshore profile (Figs. 1a and 2a).

After Line 1 was acquired for both the OBS and multichannel-seismic-reflection (MCS) passes (LA01 and LARSE01R respectively), wide-angle data from a few onland REFTEK recorders were downloaded for examination. Failure to observe individual air gun pops in these wide-angle data prompted the decision to reshoot the northeast end of Line 1, closest to Long Beach, along two additional transits to insure that this portion of the line would be recorded at least once during the late-night hours. Thus, two short sections of Line 1 using 50-m shot intervals were repeated between the north easternmost way point and Catalina Island (these were named LARSE01X for the south directed line and LARSE01Y for the north directed line (Fig. 2a)). Line LARSE01Y was acquired during the night from 0632 UTC to 1235 UTC on JD 288 (2332 L until 0535 L on 15 October 1994). While acquiring Lines 01X and 01Y we learned that OBS6 from the first OBS deployment had not been recovered, however, all the other 8 OBS's were recovered and yielded useful data. OBS6 was recovered by an unrelated vessel on 19 October 1994, during acquisition of Line 02Z.

After completing 4 repeats of Line 1 (LA01, LARSE01R, LARSE01X, and LARSE01Y), the **Ewing** made an inside turn onto LARSE transit Line TR1 at 1235 UTC on JD 288 (0535 L on 15 October 1994). Shortly after starting this line, however, the entire streamer rose to the surface and the streamer tension exceeded the usual upper limit of 3500 lbs. Fearing that the streamer had become tangled with gear or kelp, the **Ewing** quickly lowered its speed through the water and the **Ewing's** Zodiac was sent to inspect both the tail buoy and those birds that had risen to the surface. At the same time, the first several sections of the streamer were pulled in and lead foil was wrapped around each section to make the head of the streamer heavier. The **Ewing's** Zodiac removed a great deal of kelp that had been caught in the tail buoy but found none in the birds. The **Ewing's** speed was increased and the streamer was found to fly at the proper attitude and depth once again. This problem resulted in the loss of most of the data along the strike of San Pedro Basin during the LARSE transit Line TR1, and seriously degraded the easterly line to this basin from the northern end of Line 1. Data quality from the NE-SW-trending segment of TR1 from the San Pedro Basin to the landward end of Line 3, however, was satisfactory. An inside turn was made onto Line 3.

Two passes of the NE-SW-trending Line 3 (LARSE03 and LARSE03R) were made without incident and with little nearby ship traffic. The two passes required nearly 29 hours between 2146 UTC on JD 288 and 0225 UTC on JD 290 (Table 1). To reclaim the time lost to the streamer problem on TR1, Line 3 was shortened by about 18 km, making the line approximately

122 km long. Each pass was collected with an air gun repetition rate of either 50 m or 20 seconds and was recorded with the multichannel streamer. At the completion of Line 3, we made an inside turn onto transit Line TR2, which was slightly deviated to the west from our pre-cruise plan to avoid a restricted area in the vicinity of Los Angeles Airport where sewer lines extend offshore. TR2 was completed at 0458 UTC on JD 290.

We next carried out five passes on the 150-km long, N-S-trending Line 2 (Table 1). Upon reaching the start of Line 2 at its northern end, the air gun array was turned off as we performed a wide turn within the 3-mile state limit south of Malibu. This turn was completed at approximately 0551 UTC on JD 290 (2251 L on 16 October 1994). MCS data along Line 2 were first acquired using a shot interval of 50 meters ending at 0147 UTC on JD 291 (1847 L 17 October 1994). A 180° turn back onto Line 2 was completed at 0156 UTC on JD 291 (1856 L on 17 October 1994) at the southern end of the line. The 8 remaining OBSs were deployed along this line during our first pass of the line (Line LARSE02); they were programmed to start recording at 1900 L on 17 October 1994.

The second, OBS pass of Line 2 (Line LARSE02R) used a 90-sec air gun repetition rate to minimize water-wave arrivals on the OBS data (Fig. 2b). We also continued recording data with the multichannel streamer. The first two passes along Line 2 were completed without serious incident, although in the daylight hours of 18 October 1994 we noted that a small float had been snagged by a bird about 1/3 of the length of the streamer behind the ship. Our chase boat following the tail buoy was able to cut the float away from the streamer. The 3-mile limit and northern end of the OBS pass of Line 2 was reached at 1955 UTC on JD 291 (1255 L on 18 October 1994) and the air guns were turned off at that time. After another wide-turn within the 3-mile state limit, acquisition of a third pass of the northern end of the line (Line LARSE02X) commenced at 2103 UTC on JD 291 (1403 L 18 October 1994). At 0400 UTC on JD 292 (2100 L 18 October 1994) this southerly pass was completed and the ship made another 180° turn to record Line LARSE02Y during nighttime hours while steaming towards the north (Fig. 2b). The **Ewing** reached the 3-mile limit completing Line LARSE02Y at 1200 UTC on JD 292 (0500 L 19 October

1994). The **Ewing** made a final wide turn within the 3-mile limit with air guns off to begin Line LARSE02Z. The fifth and last pass along Line 2, Line LARSE02Z, was started at 1230 UTC on JD 292 (0530 L 19 October 1994) and was completed as far south as Line TR3 by 1800 UTC on JD 292 (1100 L 19 October 1994). The **Ewing** made an inside turn onto Line TR3 (Figure 1b).

Line TR3, a 49-km long line connecting Lines 1 and 2 along the center of San Pedro Basin, was completed in 6 hours at 2350 UTC on JD 292 (1650 L 19 October 1994). At this time the **Ewing** made an inside turn to reshoot Line 1 southwards towards San Clemente Island at the request of the LARSE team recording wide-angle data on land (Fig. 2a). This southerly transit of Line 1 (Line LARSE01A) was completed in 6 hours at 0640 UTC on JD 293 (2340 L 20 October 1994), and the **Ewing** turned 180º to reshoot Line 1 northwards towards Long Beach (Line LARSE01B, see Fig. 2a). The reshooting of Line 1 was completed 8 hours later at 1355 UTC on JD 293 (0655 L 20 October 1994).

After reshooting Line 1 (along Line LARSE01B), we began a series of zig-zag lines to image the Palos Verde and Newport-Inglewood fault systems while transiting southeasterly in the direction of San Diego. The first of these lines, Line LARSE04, trending ENE-WSW, was started at 1400 UTC on JD 293 (0700 L on 20 October 1994). Shortly thereafter, at 1445 UTC (0745 L), the rudder and propeller of the chase boat, **Ventura**, became snared in our multichannel streamer during the turn to Line LARSE04. The **Ewing's** Zodiac was launched in an attempt to free the chase boat, **Ventura**, but to no avail. At 1630 UTC we slowed the **Ewing** and turned off the air guns in an attempt to free the **Ventura,** effectively ending Line LARSE04. A dive boat freed the chase boat at 1700 UTC (1000 L) without damage to either boat. When retrieving the streamer at the end of the MCS data acquisition, we found that the chase boat's propeller damaged the last two sections of the streamer. Line LARSE05 was attempted but was aborted due to equipment failure.

A very clear 3.5 kHz record of the Palos Verde fault on Line LARSE04 shows roughly 40 m of recent offset on a steeply dipping scarp (Figure 6). After turning within the 3-mile-limit with our air guns off, MCS profiling on Line LARSE06a, parallel to Line 4 but located about a mile south of Line LARSE04, started at 1835 UTC (1135 L). Line LARSE06a was designed to image the Palos Verde fault system at depth. Line LARSE06a was completed in about 3 hours at 2128 UTC on JD 293 (1428 L on 20 October). An inside turn was made onto Line LARSE06b. Line LARSE06b, trending E-W, also designed to cross the Palos Verde fault, was completed in about 6 hours at 0231 UTC on JD 294 (1916 L on 20 October). A final inside turn was made onto Line LARSE06c. Our final line, Line LARSE06c, ran NW-SE about 4 miles seaward of the coastline and was designed to image a regional detachment surface first identified by Crouch and Suppe (1993). Line LARSE06c was ended after 2 hours at 0433 UTC (2133 on 20 October 1994) . During Line LARSE06c, at approximately 0330 UTC on JD 294 (2030 L on 20 October 1994), the chase boat attempted but failed to transfer two members of the science party (Rob Clayton and John McRaney) involved with the upcoming onshore explosive survey for LARSE.

At 0433 UTC on JD 294 (2130 L on 20 October 1994) we began to bring the air gun array and the streamer aboard. After the equipment was retrieved and secured on deck in about 4 1/2 hours, about 0900 UTC on JD 294 (0200 L on 20 October), we transited to port at San Diego. The **Ewing** arrived at port at San Diego at about 1446 UTC on JD 294 (0746 L on 21 October 1994) and main engines were secured at 1630 UTC on JD 294 (0930 L on 21 October 1994).

Weather conditions for the survey were generally ideal. The prevailing weather pattern consisted of calm to light winds in the late evening to early morning hours with winds picking up strength in the afternoon and early evening hours reaching highs of more than 15 knots. The highest winds (30 knots) were encountered during a storm during the first two passes of Line 1 (Lines 01 and 01R).

Operations on the R/V **Yellowfin**

Nine ocean bottom seismometers (OBS's) were deployed and recovered by the R/V **Yellowfin**, a 76-foot vessel operated by the Ocean Studies Institute, a consortium of universities in Southern California, and based in San Pedro, California. Seven OBS's used during LARSE were operated by the USGS Branch of Atlantic Marine Geology and the two other OBS's were loaned for the LARSE experiment by Dalhousie University, Halifax, Nova Scotia. Separate OBS deployments were made along Lines 1 and 2 to provide control on the shallow crustal velocities along these lines (Figure 1b and Table 3). Each OBS deployment recorded air gun signals only along the line on which it was deployed. The OBS's were concentrated on the northern ends of these lines, to help resolve the velocity structure nearest the Los Angeles Basin. OBS 8 on the Line 2 deployment was deployed to the southwest of San Clemente Island in an attempt to record reversed upper mantle refractions (Pn).

Nine OBS's along Line 1 were deployed on 12 October 1994 after being programmed to begin recording at 1600 UTC on JD 286 (0900 L on 13 October 1994). These OBSs recorded during both OBS and MCS passes of Line 1 (Lines LA01 and LARSE01R) made by the **Ewing**, and were recovered in the night and morning of 14-15 October 1994. Eight OBS's were immediately recovered from this deployment and all 8 provided useful data for Lines LA01 and LARSE01R (as well as for part of Line 1X): OBS 6 of this deployment was found floating at the surface after being lost for about 4 days. This OBS did not stay attached to its anchor and released shortly after impacting the seafloor, recording only 10 shots of Line LA01.

The remaining eight OBS's were deployed along Line LARSE02 between 0900 and 1800 UTC on JD 290 (0200 and 1100 L on 17 October 1994), and were programmed to begin recording at 0200 UTC on JD 291 (1900 L on 18 October 1994). The OBS's were recovered between 0215 and 1420 UTC on JD 292 (night and morning of 19-20 October) and thus recorded both OBS and MCS passes of Line 2 (Lines LARSE02R and LARSE02X); four OBS's recorded at least part of MCS Line LARSE02Y (Table 1). OBS 3, deployed at the intersection of Lines 2 and 3, and OBS 5, deployed south of Catalina (Table 3), were not immediately recovered from this deployment. Both were found floating at the sea surface after the LARSE MCS experiment ended. OBS 5 recorded 100 shots (12%) of Line LARSE02R before it released prematurely. OBS 3 stayed on the seafloor for nearly a day, and recorded 550 shots of Line LARSE02R (representing 66% of the line). OBS 7 from this deployment failed to record any useful data (Table 3). The total OBS data recovery rate for both deployments was about 80%. The premature releases of the OBS's were caused by a manufacturing error in the coupling springs between the OBS's and their bottom weight.

DATA PROCESSING

As described in Appendix 3, two channels from the streamer were directly written onto the navigation (NAVLOG) 3480 cartridge tapes during our leg, a near-trace (ch. 150) and a far-trace (ch. 10). After the cruise we plotted constant offset sections for all lines using the near-trace, ch. 150, located 412.5 meters behind the center of the air gun array. Processing of these data included: (1) bandpass filter from 4-8-48-60 Hz, (2) automatic gain control (AGC), using a 500-msec window, (3) a water-bottom mute (to eliminate water column noise), and (4) display.

DESCRIPTION OF THE DATA

The constant offset sections indicate the multichannel seismic-reflection data are of high quality (Figures 7-9). The sections image a number of important deformation structures in the San Pedro, Catalina, and San Nicolas Basins. Folding of the sediments south of Long Beach in San Pedro basin is well-displayed on Line 1. Line 2 imaged a relict fault south of San Clemente ridge. Line 2 also reveals that Catalina Basin is underlain by a buried basement high that trends northwest and appears to bound an active fault. Block tilting of the Santa Catalina Ridge and Pilgrim Banks is clearly shown in these profiles.

Prominent multiples were generated over the hard basement outcrops such as Santa Catalina Ridge. Several orders of multiples, which were not suppressed by any of the processing used here, are evident.

No reflections beneath the sedimentary basins are observed in the constant offset sections, so they have been plotted to a depth of 6 seconds only. No lower crustal reflections were observed in these unstacked data.

ACKNOWLEDGMENTS

We thank the Captain, crew, and Ewing-based science party, in particular Bruce Francis, Science Officer, Stefanus Budhypramono, System operator, Chuck Donaldson, ET, and Johnny DiBernardo, Chief Air Gunner, for their excellent and hard work as well as their hospitality during our leg. Mike Rawson of Lamont-Doherty Earth Observatory (LDEO) patiently answered many questions about the Ewing prior to the cruise. The US Coast Guard issued a Notice to Mariners and helped inform vessels of our activities. The US Navy granted permission to enter waters in their jurisdiction on the western end of Line 3. The Los Angeles Fisherman's Association notified their members of our activities. Peter Buhl of LDEO was a valuable resource aboard the Ewing during the cruise. Jim Vaughan, USGS, provided the military sonobuoys. Greg Miller, Uri ten Brink, and Doug Foster of the USGS and the Captain of the R/V Yellowfin kept us up-to-date on the status of the OBS deployments. Gary Fuis, USGS, Tom Henyey, USC, and David Okaya, USC, helped to plan and direct our operations at sea. Jon Childs arranged for the ProMAX system used to transcribe the 3480 cartridges. We thank the IRIS/PASSCAL facility (at Stanford) for providing the REFTEK instruments used in this experiment. Joe Jackson videotaped our work on the Ewing. Pat Jorgensen and Jim Mori, both of the USGS, arranged a press conference the day before the cruise. John Pittman of Vessel Assist Cabrillo of San Pedro provided a chase boat for Line 2. Beth Ambos, CSLB, and family provided lodgings to T.M. Brocher prior to the cruise. Jon Childs, USGS, wrote Appendix 2. Stefanus Budhypramono, LDEO, wrote Appendix 4. Gary Fuis, USGS, drafted Figures 1a and 1b, modified here. Bruce Francis, LDEO, drafted Figures 2 and 3, modified here. Pat Hart provided useful comments on an earlier draft of this report and generated Figure 5.

This work was supported by the National Earthquake Hazards Reduction Program, the National Science Foundation, and the Southern California Earthquake Center.

REFERENCES CITED

Barry, K.M., D.A. Cravers, and C.W. Kneale, 1975, Recommended standards for digital tape formats: *Geophysics, v. 40,* p. 344-352.

Crouch, J.S., and J. Suppe, 1993, Late Cenozoic tectonic evolution of the Los Angeles basin and inner California borderland: A model for core complex-like crustal extension, *Geological Society of America, Bulletin*, v. 105, p. 1415-1434.

Davis, T.L. and J.S. Namson, 1994, A balanced cross-section of the 1994 Northridge earthquake, southern California, *Nature, v. 372,* p. 167-169.

Shaw, J.H., S.C. Hook, and J. Suppe, 1994, Structural trend analysis by axial surface mapping, *AAPG Bulletin, v. 78,* p. 700-721.

Shaw, J.H., and J. Suppe, 1994, Active faulting and growth folding in the eastern Santa Barbara Channel, California, *Geol. Society of America, Bulletin, v. 106,* p. 607-626.

Stein, R.S., and G.C.P. King, 1984, Seismic potential revealed by surface folding: 1983 Coalinga, California, earthquake, *Science, v. 224,* p. 869-872.

Stein, R.S., and R.S. Yeats, 1989, Hidden earthquakes, *Scientific American, June 1989,* p. 48-57.

Wright, T., 1991, Structural geology and tectonic evolution of the Los Angeles Basin, California, in K.T. Biddle, ed., Active margin basins: *AAPG Memoir 52,* p. 35-134.

SEG Subcommittee on Field Tape Standards, 1994, Digital field tape format standards - SEG-D, Revision 1, *Geophysics, v. 59,* p. 668-684.

U.S. Geological Survey and Southern California Earthquake Center, 1994, The magnitude 6.7 Northridge, California, earthquake of 17 January 1994, *Science, v. 266*, p. 389-397.

TABLE 1. R/V **Ewing** LARSE Line Start and End Times and Locations

		Start of Line			End of Line	
Line No.	UTC Day:HrMn	Lat. (N) Deg. Min.	Long. (W) Deg. Min.	UTC Day:HrMn	Lat. (N) Deg. Min.	Long. (W) Deg. Min.
01	286:1849	33 38.191	118 07.055	287:0541	32 56.869	118 25.333
01R	287:1155	33 49.475	118 07.194	288:0124	33 37.276	118 11.621
01X	288:0128	33 36.951	118 11.505	288:0632	33 15.103	118 15.692
01Y	288:0632	33 15.091	118 15.704	288:1235	33 35.179	118 12.782
TR1	288:1236	33 35.125	118 12.855	288:2144	33 49.777	118 30.522
03	288:2145	33 49.768	118 30.569	289:1210	33 28.300	119 42.396
03R	289:1211	33 28.308	119 42.303	290:0237	33 51.075	118 27.880
(03R	289:1211	33 28.308	119 42.303	290:0225	33 50.479	118 28.323)
TR2	290:0238	33 51.147	118 27.950	290:0459	33 59.144	118 35.305
(TR2	290:0239	33 51.171	118 27.983	290:0458	33 59.118	118 35.302)
02	290:0517	34 00.507	118 35.383	291:0154	32 38.305	118 43.391
(02	290:0551	33 59.170	118 34.841	291:0147	32 37.892	118 43.487)
02R	291:0155	32 38.363	118 43.386	291:1956	33 59.187	118 35.040
(02R	291:0156	32 38.444	118 43.387	291:1955	33 58.784	118 35.080)
02X	291:2052	33 58.996	118 34.911	292:0404	33 26.080	118 40.439
(02X	291:2103	33 58.203	118 35.002	292:0359	33 26.440	118 40.279)
02Y	292:0405	33 26.060	118 40.465	292:1231	33 59.090	118 35.130
(02Y	292:0406	33 26.008	118 40.505	292:1232	33 58.991	118 35.033)
02Z	292:1329	33 59.209	118 34.984	292:1750	33 41.121	118 37.782
(02Z	292:1336	33 58.754	118 35.088	292:1743	33 41.548	118 38.042)
TR3	292:1751	33 41.082	118 37.708	292:2349	33 25.458	118 11.820
(TR3	292:1753	33 41.043	118 37.614	292:2350	33 25.454	118 11.805)
01A	292:2351	33 25.314	118 11.858	293:0640	32 58.774	118 23.739
(01A	292:2352	33 25.218	118 11.890	293:0558	33 00.418	118 23.248)
01B	293:0640	32 58.815	118 23.759	293:1356	33 28.895	118 10.714
(01B	293:0630	32 58.610	118 23.032	293:1355	33 28.797	118 10.739)
04	293:1400	33 29.156	118 10.808	293:1644	33 32.535	118 02.362
(04	293:1355	33 28.797	118 10.739	293:1630	33 32.385	118 02.975)
05	293:1712	33 32.892	118 00.680	293:1835	33 32.842	117 56.077
06a	293:1837	33 32.829	117 56.121	293:2128	33 29.735	118 09.673
06b	293:2147	33 28.663	118 09.354	294:0231	33 24.877	117 46.034
06c	294:0242	33 24.300	117 45.355	294:0433	33 17.037	117 41.468

Parens indicate times and locations noted in MCS log aboard ship; other times and locations taken from digital shot log provided by Stephanus Budhypramono of LDEO.

TABLE 2. Sonobuoy Locations

Sono-buoy No.	Line No.	Launch Time and Location UTC Day:HrMn	Lat. (N) Deg. Min.	Long. (W) Deg. Min.	MCS File No.	Water Temp. (°C)	Drift (knots)
01	03	289:0100	33 44.7679	118 46.9194	648	18.7	
02	03R	290:0046	33 48.1	118 36.2	2289	18.1	0.5

TABLE 3. Ocean Bottom Seismometer Locations and Depths

Line 1

Station Name	OBS Number	Line 01R FFID	Latitude (N) Deg. Min.	Longitude (W) Deg. Min.	Depth (m)
OBS1	A3	2217	33 34.0844	118 08.7095	97
OBS2	A1	2107	33 31.1492	118 09.8185	321
OBS3	A2	1926	33 26.5097	118 11.5804	723
OBS4	DAL A	1713	33 21.0082	118 13.4897	711
OBS5	DAL C	1549	33 16.8277	118 15.1957	177
OBS6*	C1	1387	33 12.8067	118 16.5421	1134
OBS7	C9	1137	33 06.7002	118 20.1462	1158
OBS8	C4	904	33 01.0848	118 23.2386	798
OBS9	C3	722	32 56.3934	118 25.2850	1191-1196#

Line 2

Station Name	OBS Number	Line 02 FFID	Latitude (N) Deg. Min.	Longitude (W) Deg. Min.	Depth (m)
OBS1	C4	124	33 58.6342	118 34.9445	77
OBS2	C3	337	33 53.0789	118 36.0271	79
OBS3*	C9	532	33 47.8420	118 37.0280	833
OBS4	A1	720	33 42.9050	118 37.8090	705
OBS5*	A2	1010	33 35.2470	118 39.3110	618
OBS6	A3	1511	33 21.9648	118 40.6503	1200
OBS7$	DAL C	1868	33 12.4439	118 41.3244	1330-1340#
OBS8	DAL A	2510	32 55.2289	118 42.5562	1210-1215#

*OBS was not immediately recovered but was found drifting a few days after the others were retrieved.
#The depth-sounder on the Yellowfin could not provide more accurate readings at these depths.
$Failed to record any useful data.

APPENDIX 1: Abridged Ewing Shot Times and Locations

Year:Date:Hr:Min:Sec FFID Lat. Long. Line Number

94+286:18:49:17.736 00101 N 33 38.1910 W 118 07.0551 LA01
94+286:19:00:18.473 00112 N 33 37.5247 W 118 07.3583 LA01
94+286:20:00:18.483 00172 N 33 33.7540 W 118 08.9776 LA01
94+286:21:00:20.715 00232 N 33 29.8386 W 118 10.2979 LA01
94+286:22:00:21.955 00292 N 33 25.8759 W 118 11.6982 LA01
94+286:23:00:24.907 00352 N 33 21.7805 W 118 13.1994 LA01
94+287:00:00:28.404 00412 N 33 17.8508 W 118 14.5750 LA01
94+287:01:00:29.640 00472 N 33 14.2768 W 118 16.2731 LA01
94+287:02:00:30.687 00532 N 33 10.7990 W 118 18.2605 LA01
94+287:03:00:31.687 00592 N 33 07.0360 W 118 20.1193 LA01
94+287:04:00:34.916 00652 N 33 03.3934 W 118 22.0520 LA01
94+287:05:00:36.116 00712 N 32 59.5526 W 118 23.9744 LA01
94+287:05:41:37.305 00753 N 32 56.8693 W 118 25.3331 LA01

94+287:11:55:42.459 00105 N 32 49.4752 W 118 07.1937 LARSE01R
94+287:12:00:08.057 00118 N 32 49.6061 W 118 07.5666 LARSE01R
94+287:13:00:03.960 00297 N 32 51.5937 W 118 12.7275 LARSE01R
94+287:14:00:20.228 00474 N 32 53.6265 W 118 17.7704 LARSE01R
94+287:15:00:10.140 00644 N 32 55.3614 W 118 22.7083 LARSE01R
94+287:16:00:18.452 00806 N 32 58.6314 W 118 24.5302 LARSE01R
94+287:17:00:03.958 00979 N 33 02.8678 W 118 22.2462 LARSE01R
94+287:18:00:19.628 01154 N 33 07.1215 W 118 20.0302 LARSE01R
94+287:19:00:18.668 01323 N 33 11.2740 W 118 17.8620 LARSE01R
94+287:20:00:20.480 01495 N 33 15.4655 W 118 15.6491 LARSE01R
94+287:21:00:03.943 01666 N 33 19.8046 W 118 13.8989 LARSE01R
94+287:22:00:11.184 01838 N 33 24.2134 W 118 12.3503 LARSE01R
94+287:23:00:00.920 02011 N 33 28.6400 W 118 10.7141 LARSE01R
94+288:00:00:08.128 02186 N 33 33.2089 W 118 10.7523 LARSE01R
94+288:01:00:02.001 02353 N 33 37.0877 W 118 12.6862 LARSE01R
94+288:01:24:01.118 02414 N 33 37.2756 W 118 11.6212 LARSE01R

94-288:01:28:30.803 00101 N 33 36.9514 W 118 11.5048 LARSE01X
94+288:02:00:05.743 00174 N 33 34.5805 W 118 11.0279 LARSE01X
94+288:03:00:20.624 00339 N 33 30.2560 W 118 10.1924 LARSE01X
94+288:04:00:17.875 00513 N 33 25.7471 W 118 11.6947 LARSE01X
94+288:05:00:13.976 00684 N 33 21.3779 W 118 13.3172 LARSE01X
94+288:06:00:21.627 00854 N 33 17.0405 W 118 14.8050 LARSE01X
94+288:06:32:37.925 00935 N 33 15.1029 W 118 15.6916 LARSE01X

94+288:06:32:56.018 00101 N 33 15.0910 W 118 15.7035 LARSE01Y
94+288:07:00:18.578 00153 N 33 14.5518 W 118 16.9116 LARSE01Y
94+288:08:00:18.152 00314 N 33 17.4955 W 118 14.6791 LARSE01Y
94+288:09:00:17.824 00478 N 33 21.7296 W 118 13.3686 LARSE01Y
94+288:10:00:21.044 00644 N 33 25.9674 W 118 11.7275 LARSE01Y
94+288:11:00:17.286 00814 N 33 30.2943 W 118 10.0756 LARSE01Y
94+288:12:00:04.803 00976 N 33 34.5261 W 118 11.0721 LARSE01Y
94+288:12:35:17.847 01068 N 33 35.1791 W 118 12.7817 LARSE01Y

Line TR1a
94-288:12:36:27.396 00101 N 33 35.1254 W 118 12.8549 LARSETR1

94+288:13:00:07.504 00167 N 33 33.8226 W 118 14.2356 LARSETR1
94+288:14:00:03.490 00322 N 33 30.7704 W 118 17.3762 LARSETR1
94+288:14:30:28.903 00393 N 33 30.2095 W 118 19.3732 LARSETR1

Line TR1b
94-288:17:47:10.731 00101 N 33 34.3285 W 118 31.1544 LARSETR1
94+288:18:00:08.860 00138 N 33 35.1506 W 118 31.8033 LARSETR1
94+288:19:00:01.583 00312 N 33 39.4213 W 118 33.4989 LARSETR1
94+288:20:00:02.447 00488 N 33 43.8144 W 118 31.5320 LARSETR1
94+288:21:00:19.953 00663 N 33 48.1076 W 118 29.3360 LARSETR1
94+288:21:44:45.676 00783 N 33 49.7766 W 118 30.5224 LARSETR1

94+288:21:45:16.921 00101 N 33 49.7675 W 118 30.5687 LARSE03
94+288:22:00:18.422 00145 N 33 49.4030 W 118 31.9168 LARSE03
94+288:23:00:12.138 00314 N 33 47.9471 W 118 36.9643 LARSE03
94+289:00:00:00.042 00476 N 33 46.3380 W 118 41.7889 LARSE03
94+289:01:00:12.994 00648 N 33 44.7615 W 118 46.9474 LARSE03
94+289:02:00:09.955 00817 N 33 43.3139 W 118 52.1335 LARSE03
94+289:03:00:08.048 00996 N 33 41.5772 W 118 57.5282 LARSE03
94+289:04:00:05.970 01184 N 33 40.0384 W 119 03.2405 LARSE03
94+289:05:00:17.889 01362 N 33 38.2112 W 119 08.4451 LARSE03
94+289:06:00:11.771 01537 N 33 36.8048 W 119 13.7917 LARSE03
94+289:07:00:21.272 01713 N 33 35.2201 W 119 19.0487 LARSE03
94+289:08:00:11.164 01873 N 33 33.8611 W 119 23.8832 LARSE03
94+289:09:00:22.406 02036 N 33 32.2860 W 119 28.7390 LARSE03
94+289:10:00:16.666 02200 N 33 30.6818 W 119 33.6381 LARSE03
94+289:11:00:04.329 02367 N 33 29.4110 W 119 38.7410 LARSE03
94+289:12:00:13.780 02524 N 33 28.6629 W 119 43.0103 LARSE03
94+289:12:10:24.907 02546 N 33 28.3001 W 119 42.3963 LARSE03

94+289:12:11:30.943 00101 N 33 28.3078 W 119 42.3029 LARSE03R
94+289:13:00:09.192 00230 N 33 29.4439 W 119 38.2608 LARSE03R
94+289:14:00:07.055 00402 N 33 30.9287 W 119 33.0648 LARSE03R
94+289:15:00:01.568 00581 N 33 32.5004 W 119 27.6512 LARSE03R
94+289:16:00:17.727 00757 N 33 34.1488 W 119 22.4373 LARSE03R
94+289:17:00:08.771 00923 N 33 35.8234 W 119 17.5013 LARSE03R
94+289:18:00:08.189 01100 N 33 37.2967 W 119 12.0843 LARSE03R
94+289:19:00:09.041 01276 N 33 38.7931 W 119 06.7238 LARSE03R
94+289:20:00:15.892 01460 N 33 40.4540 W 119 01.1934 LARSE03R
94+289:21:00:02.038 01645 N 33 42.1461 W 118 55.6502 LARSE03R
94+289:22:00:03.040 01822 N 33 43.6823 W 118 50.3249 LARSE03R
94+289:23:00:16.347 01991 N 33 45.2109 W 118 45.2325 LARSE03R
94+290:00:00:01.250 02159 N 33 46.7763 W 118 40.1895 LARSE03R
94+290:01:00:03.223 02329 N 33 48.4177 W 118 35.1116 LARSE03R
94+290:02:00:16.623 02491 N 33 49.9201 W 118 30.2992 LARSE03R
94+290:02:37:25.192 02587 N 33 51.0747 W 118 27.8797 LARSE03R

94+290:02:38:46.229 00101 N 33 51.1466 W 118 27.9502 LARSETR2
94+290:03:00:23.054 00152 N 33 52.0566 W 118 29.4076 LARSETR2
94+290:04:00:19.519 00319 N 33 54.8050 W 118 33.7771 LARSETR2
94+290:04:59:09.433 00494 N 33 59.1441 W 118 35.3047 LARSETR2

94-290:05:17:27.928 00101 N 34 00.5065 W 118 35.3833 LARSE02
94+290:06:00:17.404 00129 N 33 58.5106 W 118 35.1231 LARSE02

94+290:07:00:14.853 00292 N 33 54.2299 W 118 35.8275 LARSE02
94+290:08:00:03.996 00442 N 33 50.2701 W 118 36.4737 LARSE02
94+290:09:00:11.887 00599 N 33 46.0755 W 118 37.1957 LARSE02
94+290:10:00:07.081 00762 N 33 41.7912 W 118 38.1739 LARSE02
94+290:11:00:11.012 00924 N 33 37.5272 W 118 38.8884 LARSE02
94+290:12:00:12.071 01086 N 33 33.2521 W 118 39.5734 LARSE02
94+290:13:00:19.431 01243 N 33 29.0833 W 118 40.2080 LARSE02
94+290:14:00:21.256 01397 N 33 25.0075 W 118 40.2710 LARSE02
94+290:15:00:24.276 01543 N 33 21.1104 W 118 40.4225 LARSE02
94+290:16:00:10.167 01692 N 33 17.0818 W 118 40.3679 LARSE02
94+290:17:00:10.257 01842 N 33 13.1128 W 118 40.5788 LARSE02
94+290:18:00:20.462 01978 N 33 09.5246 W 118 40.5967 LARSE02
94+290:19:00:19.537 02112 N 33 05.9164 W 118 40.6276 LARSE02
94+290:20:00:04.363 02261 N 33 01.8875 W 118 40.6963 LARSE02
94+290:21:00:22.191 02408 N 32 58.0202 W 118 41.1395 LARSE02
94+290:22:00:04.289 02556 N 32 54.0071 W 118 41.6480 LARSE02
94+290:23:00:08.091 02723 N 32 49.5139 W 118 42.1385 LARSE02
94+291:00:00:16.082 02898 N 32 44.8263 W 118 42.5964 LARSE02
94+291:01:00:03.382 03077 N 32 40.0689 W 118 43.1260 LARSE02
94+291:01:54:01.400 03215 N 32 38.3049 W 118 43.3906 LARSE02

94+291:01:54:58.840 00101 N 32 38.3632 W 118 43.3877 LARSE02R
94+291:02:00:58.973 00105 N 32 38.7186 W 118 43.2985 LARSE02R
94+291:03:00:59.366 00145 N 32 42.5931 W 118 43.0442 LARSE02R
94+291:03:59:30.434 00184 N 32 46.6377 W 118 42.4137 LARSE02R
94+291:04:59:31.872 00224 N 32 50.6815 W 118 41.9928 LARSE02R
94+291:05:59:32.775 00264 N 32 54.9600 W 118 41.5864 LARSE02R
94+291:06:59:33.541 00304 N 32 59.4535 W 118 40.9761 LARSE02R
94+291:07:59:36.050 00344 N 33 03.6547 W 118 40.7081 LARSE02R
94+291:08:59:37.022 00384 N 33 08.4115 W 118 40.7063 LARSE02R
94+291:09:59:40.175 00424 N 33 13.0746 W 118 40.6950 LARSE02R
94+291:10:59:40.410 00464 N 33 17.7123 W 118 40.4246 LARSE02R
94+291:11:59:41.015 00504 N 33 22.3501 W 118 40.3197 LARSE02R
94+291:12:59:41.279 00544 N 33 27.2905 W 118 40.2475 LARSE02R
94+291:13:59:43.062 00584 N 33 32.1174 W 118 39.8743 LARSE02R
94+291:14:59:44.269 00624 N 33 36.7405 W 118 38.9881 LARSE02R
94+291:15:59:46.210 00664 N 33 41.1264 W 118 38.0487 LARSE02R
94+291:16:59:47.300 00704 N 33 45.6855 W 118 37.5693 LARSE02R
94+291:17:59:48.515 00744 N 33 50.2230 W 118 36.7155 LARSE02R
94+291:18:59:50.415 00784 N 33 54.8195 W 118 35.7287 LARSE02R
94+291:19:56:51.976 00822 N 33 59.1866 W 118 35.0395 LARSE02R
94+291:19:56:51.976 00822 N 33 59.1866 W 118 35.0395 LARSE02R

94-291:20:52:55.502 00101 N 33 58.9955 W 118 34.9105 LARSE02X
94-291:21:00:15.675 00123 N 33 58.4382 W 118 34.9741 LARSE02X
94+291:22:00:03.602 00275 N 33 54.1497 W 118 35.7090 LARSE02X
94+291:23:00:07.734 00455 N 33 49.5534 W 118 36.5912 LARSE02X
94+292:00:00:08.587 00635 N 33 44.7232 W 118 37.6345 LARSE02X
94+292:01:00:12.467 00815 N 33 40.0411 W 118 38.3838 LARSE02X
94+292:02:00:16.561 00995 N 33 35.5514 W 118 39.0806 LARSE02X
94+292:03:00:16.490 01175 N 33 31.0242 W 118 39.8653 LARSE02X
94+292:04:00:18.522 01355 N 33 26.3980 W 118 40.2904 LARSE02X
94+292:04:04:58.929 01369 N 33 26.0795 W 118 40.4389 LARSE02X

94+292:04:05:21.494 00101 N 33 26.0601 W 118 40.4650 LARSE02Y
94+292:05:00:02.389 00265 N 33 27.1016 W 118 40.4038 LARSE02Y
94+292:06:00:06.067 00445 N 33 31.2086 W 118 39.9953 LARSE02Y
94+292:07:00:06.608 00625 N 33 35.5913 W 118 39.2658 LARSE02Y
94+292:08:00:10.380 00805 N 33 39.8117 W 118 38.4313 LARSE02Y
94+292:09:00:15.273 00985 N 33 43.9213 W 118 37.7421 LARSE02Y
94+292:10:00:15.065 01165 N 33 48.0791 W 118 36.9137 LARSE02Y
94+292:11:00:17.304 01345 N 33 52.4458 W 118 36.0768 LARSE02Y
94+292:12:00:00.702 01524 N 33 56.7512 W 118 35.5050 LARSE02Y
94+292:12:31:41.399 01619 N 33 59.0900 W 118 35.1297 LARSE02Y

94-292:13:29:27.255 00101 N 33 59.2088 W 118 34.9838 LARSE02Z
94+292:14:00:06.400 00193 N 33 57.2305 W 118 35.3422 LARSE02Z
94+292:15:00:08.704 00373 N 33 53.2898 W 118 36.1026 LARSE02Z
94+292:16:00:10.146 00553 N 33 48.8349 W 118 36.7070 LARSE02Z
94+292:17:00:12.928 00733 N 33 44.6393 W 118 37.4671 LARSE02Z
94+292:17:50:16.318 00883 N 33 41.1206 W 118 37.7817 LARSE02Z

94+292:17:51:16.279 00101 N 33 41.0819 W 118 37.7084 LARSETR3
94+292:19:00:17.389 00308 N 33 38.2294 W 118 32.7562 LARSETR3
94+292:20:00:01.172 00487 N 33 35.5438 W 118 28.4572 LARSETR3
94+292:21:00:02.924 00667 N 33 32.9193 W 118 23.7531 LARSETR3
94+292:22:00:05.387 00847 N 33 30.4232 W 118 19.0269 LARSETR3
94+292:23:00:09.728 01027 N 33 27.8195 W 118 14.6585 LARSETR3
94-292:23:49:10.440 01174 N 33 25.4579 W 118 11.8203 LARSETR3

94-292:23:51:10.581 00101 N 33 25.3143 W 118 11.8581 LARSE01A
94+293:00:00:09.301 00128 N 33 24.6750 W 118 12.0683 LARSE01A
94+293:01:00:10.601 00308 N 33 20.3659 W 118 13.7052 LARSE01A
94+293:02:00:14.052 00488 N 33 16.0679 W 118 15.3151 LARSE01A
94+293:03:00:15.753 00668 N 33 11.9929 W 118 17.5168 LARSE01A
94+293:04:00:18.514 00848 N 33 07.9846 W 118 19.7611 LARSE01A
94+293:05:00:02.909 01027 N 33 04.0656 W 118 21.5309 LARSE01A
94+293:06:00:03.221 01207 N 33 00.2975 W 118 23.2942 LARSE01A
94+293:06:40:04.022 01327 N 32 58.7739 W 118 23.7394 LARSE01A

94+293:06:40:41.713 00101 N 32 58.8149 W 118 23.7586 LARSE01B
94+293:07:00:01.153 00159 N 33 00.1870 W 118 23.5451 LARSE01B
94+293:08:00:03.507 00339 N 33 04.2791 W 118 21.4781 LARSE01B
94+293:09:00:05.874 00519 N 33 07.9989 W 118 19.4876 LARSE01B
94+293:10:00:08.149 00699 N 33 11.7962 W 118 17.6380 LARSE01B
94+293:11:00:11.048 00879 N 33 15.8636 W 118 15.6575 LARSE01B
94+293:12:00:14.169 01059 N 33 20.2040 W 118 13.6493 LARSE01B
94+293:13:00:15.813 01239 N 33 24.6972 W 118 12.0093 LARSE01B
94+293:13:56:16.171 01407 N 33 28.8957 W 118 10.7140 LARSE01B

94+293:14:00:13.799 00101 N 33 29.1561 W 118 10.8084 LARSE04
94+293:15:00:16.574 00151 N 33 31.1685 W 118 08.3868 LARSE04
94+293:16:00:19.087 00331 N 33 31.9416 W 118 04.5500 LARSE04
94-293:16:44:02.473 00462 N 33 32.5354 W 118 02.3622 LARSE04

94-293:17:12:13.662 00101 N 33 32.8920 W 118 00.6802 MARSE05
94-293:17:18:44.404 00104 N 33 33.0136 W 118 00.1301 lARSE05
94-293:17:45:12.836 00101 N 33 33.4681 W 117 57.7723 test

94-293:18:28:19.082 00101 N 33 32.9983 W 117 55.5490 LARSE05
94+293:18:35:11.795 00111 N 33 32.8422 W 117 56.0770 larse05

Line LARSE06a
94-293:18:35:45.905 00101 N 33 32.8290 W 117 56.1213 LARSE06
94+293:19:00:04.281 00174 N 33 32.2586 W 117 57.9749 LARSE06
94+293:20:00:06.283 00354 N 33 31.3082 W 118 02.7146 LARSE06
94+293:21:00:08.775 00534 N 33 30.2118 W 118 07.4535 LARSE06
94+293:21:28:09.762 00618 N 33 29.7351 W 118 09.6726 LARSE06

Line LARSE06b
94+293:21:47:10.528 00675 N 33 28.6632 W 118 09.3539 LARSE06
94+293:22:00:11.057 00714 N 33 28.4705 W 118 08.2971 LARSE06
94+293:23:00:13.811 00894 N 33 27.9199 W 118 03.3360 LARSE06
94+294:00:00:16.250 01074 N 33 26.9317 W 117 58.3716 LARSE06
94+294:01:00:18.513 01254 N 33 26.1537 W 117 53.4019 LARSE06
94+294:02:00:18.913 01434 N 33 25.2776 W 117 48.5949 LARSE06
94+294:02:31:01.953 01526 N 33 24.8771 W 117 46.0337 LARSE06

Line LARSE06c
94+294:02:42:01.143 01559 N 33 24.2997 W 117 45.3553 LARSE06
94+294:03:00:01.848 01613 N 33 23.0430 W 117 44.6647 LARSE06
94+294:04:00:02.545 01793 N 33 19.0806 W 117 42.6310 LARSE06
94-294:04:31:30.294 01885 N 33 17.0371 W 117 41.4682 LARSE06

APPENDIX 2. DMS-2000 Recording System

This Appendix presents notes on DMS-2000 seismic recording system on the **R/V Maurice Ewing** and the SEG-D data format in which we recorded MCS data on the **Ewing**.

DMS-2000 Recording System

The DMS-2000 records demultiplexed seismic data in a standard SEG-D format (SEG Subcommittee on Field Tape Standards, 1994), using a 20-bit (2.5 bytes per sample) recording format. Data logged from peripheral systems (bird controller, gun controller, navigation, etc.) are not written to the SEG-D header blocks, but are rather recorded in a special auxiliary data trace, referred to in the Digicon documentation as SEGD/Trace0 (Rtrace zeroS). The SEG-D General Header (the header that accompanies each shot record), contains the shot number and shot time to the nearest second.

For EW94-15, the DMS-2000 was configured to record 180 data channels from 46 four-channel digitizing modules (or "cans"). Only 40 of these cans were actually in use in the streamer, resulting in 160 active channels, numbered 1-160. Channel 1 is the far channel, 160 the near channel. Two channels on-board ship (173 and 174) were used to record the sonobuoy receivers. The remaining channels (161-172, 175-180) are physically on tape, but contain no data. Trace0 consists of a 4051-byte data trace preceding the demultiplexed seismic data, with a channel designation -1. It is flagged by the system as an auxiliary trace.

The DMS-2000 also writes a secondary data tape, referred to as the NAVLOG tape. This is recorded in format identical to the SEG-D data tape, but contains only three channels - Trace0 and two data channels. For EW94-15 these were channels 10 and 150, a far-trace and a relative near-trace channel. (Channels to be forked to the NAVLOG tape are selected in the CEO SOL/EOL Auto-Start-End menu of the DMS-2000 system.)

SEG-D Format

The basic layout of the SEG-D tape is: size in bytes

```
General Header      -            96 (three 32-byte blocks)
    IBG             |
Trace0 record       |            4051 (variable-length sections)
    IBG             |    S
Data Channel 1      |    H  RECL*2.5 + 20-byte trace header
    IBG             |    O
Data Channel 2      |    T       RECL*2.5 + 20-byte trace header
    IBG             |                       :
     :              |    1                  :
     :              |                       :
Data Channel 184    |            RECL*2.5 + 20-byte trace header
    IBG             |
    EOF             -

General Header  -           96 (three 32-byte blocks)
    IBG             |
Trace0 record       |    S       4051 (variable-length sections)
    IBG             |    H
Data Channel 1      |    O       RECL*2.5 + 20-byte trace header
     :              |    T                  :
     :              |                       :
Data Channel 184    |    2       RECL*2.5 + 20-byte trace header
    IBG             |
    EOF             -

                    :
                    :
General Header  -           96 (three 32-byte blocks)
    IBG             |    S
Trace0 record       |    H  4051 (variable-length sections)
    IBG             |    O
Data Channel 1      |    T       RECL*2.5 + 20-byte trace header
     :              |                       :
     :              |    N             :
Data Channel 184    |            RECL*2.5 + 20-byte trace header
    EOF             -

    EOT
```

General Header

The General Header consists of three 32-byte blocks, and contains the following relevant fields:

byte number	data
1-2	FFID
3-4	SEG-D format code (8015 - 20-bit binary demux)
5-6	not used
7-8	shotpoint
9-10	?? (791)
11	year (94)
12-13	day of year
14	shot hour (GMT)
15	shot minute (GMT)
16	shot second (GMT)

These values are recorded in Binary-Coded Decimal (BCD) notation, and are therefore recognizable in a hex dump. The day/hour/minute/second fields above are standard SEG-Y, but the shotpoint location is not defined by the standard. Software that reads SEG-D, such as ProMAX or DISCO, will therefore probably read the shot times, but not the shot points. The location of the shotpoint field must be explicitly defined in the input module. For example, in ProMAX, it is necessary to select "Remap SEGD main header values" in the SEG-D input module, and indicate something like:

Input/override main header entries SOURCE,,4B,,,6.5/

where 6.5 indicates the starting location in the header record for the 4-digit BCD value for shotpoint, which is mapped onto the header value SOURCE. The odd value (6.5) for starting location is a peculiarity of ProMAX. ProMAX SEGD input also converts the shot time to absolute seconds stored in a header word TIM_SHOT. You may choose to explicitly identify the time by hour, minute, and second, with an Input/override entry like:

SOURCE,,4B,,,6.5/HR_SHOT,GMT SHOT HOUR,2B,,,13.4/MIN_SHOT,
GMT SHOT MINUTE,2B,,,14.5/SEC_SHOT,GMT SHOT SECOND,2B,,,15.5/

Trace0

Trace0 contains a wealth of information about the system (e.g., seismic bird information, gun shooting parameters), much of which is also available from other shipboard logging systems. Trace0 data is not accessible from conventional SEGD input software; for access to it, one is advised to use John Diebold's segd_dump program, which reads and reformats to disk various selected portions of Trace0 (Internet address: johnd@lamont.ldgo.columbia.edu). Of course, dumping the Trace0 records from the NAVLOG tapes is much more efficient than reading the data tapes.

A note regarding the Trace0 positional information.

Navigational data is passed from the navigational computer aboard the **Ewing** ("Moray") to the DMS-2000 for inclusion in Trace0, where it is stored in Section 11, the "Magnavox Nav

Data Block". (Digicon uses Magnavox navigational systems on their vessels). This 211-byte navblock contains latitude and longitude fixes for each shot, which can be read with segd_dump. These positions, however, are "real-time" solutions that have not been adjusted or corrected by the post-processing that is done daily on-board the vessel. The 20-byte individual Demux Trace Headers which precede each data trace have little information of use to the processor, nor does the SEG-D standard suggest that they should.

Tape Errors

The recurring, persistent 3480 tape drive errors reported on previous Ewing cruises were resolved prior to EW94-15. However, a few SQRT errors did occur, resulting in two shot records being concatenated into one file, with the second record overwriting some portion of the previous one. These files have a variable number of traces, in excess of the normal 180 and were noted in observer logs when possible. The processing flow must be able to read these abnormal files, and pad the channels to create normal ensembles.

CEO/CSRU and TAGS Logs

The DMS-2000 system also maintains logs and error files of the recording system (CSRU) and the air gun control system (TAGS). The CSRU files are named 'line_id'.rul and 'line_id'.rue for the log and error files, respectively. The corresponding TAGS files are 'line_id'.tal and 'line_id'.tae. All of the information in the TAGS error file is repeated in the TAGS log file, and the CSRU error and log files are complementary. These files are written to DOS floppy disks with the CEO File Handler.

Precise Shot Timing And Location

Processed GPS shot locations and shot-times (precise to 1 ms from the GPS receiver) are available in a separate file, but are not contained in the SEG-D records.

APPENDIX 3. EWING Multichannel Seismic Reflection Tape Log

Notes: 160 Channels, 16 Sec Record, 2 ms Sample Rate
180 channels where written to tape but only 160 channels are MCS.
Sonobuoy channels: 173,174

3480 CARTRIDGE to 8MM EXABYTE TAPE TRANSFER

Line LARSE 01 was an OBS line without MCS recording

Start Line LARSE 01R

Exabyte Tape: LA01 Line: LARSE 01R JD 287 1156Z

3480 Cartridge No.	FFID Range	Shot Point Range
1	101-153	104-156
2	154-206	157-209
3	207-259	210-262
4	260-312	263-315
5	313-365	316-368

Exabyte Tape: LA02 Line: LARSE 01R JD 287

3480 Cartridge No.	FFID Range	Shot Point Range
6	366-418	369-421

Exabyte Tape: LA03 Line: LARSE 01R

3480 Cartridge No.	FFID Range	Shot Point Range
7	419-471	422-474
8	472-524	475-527
9	525-577	528-580
10	578-630	581-633
11	631-683	634-686

Exabyte Tape: LA04 Line: LARSE 01R

3480 Cartridge No.	FFID Range	Shot Point Range
12	684-736	687-739
13	737-789	740-792
14	790-842	793-845
15	843-895*	846-898*
16	896-948	899-951

***3480 Cartridge No. 15: Write Error, FFID 891 bad, FFID 892-894 do not exist**

Exabyte Tape: LA05 Line: LARSE 01R

3480 Cartridge No.	FFID Range	Shot Point Range
17	949-1001	952-1004
18	1002-1054	1005-1057
19	1055-1103*	1058-1106*

***Abnormal termination 3480 Cartridge No. 19**

Exabyte Tape: LA06 Line: LARSE 01R

3480 Cartridge No.	FFID Range	Shot Point Range
19	1104-1107*	1107-1110*
20	1108-1160	1111-1163
21	1161-1213	1164-1217
22	1214-1266	1218-1270
23	1267-1319	1271-1323
24	1320-1372	1324-1376

***Resume with last files of 3480 cartridge No. 19. File 1342 may be bad.**

Exabyte Tape: LA07 Line: LARSE 01R JD 287 1919-2110Z

3480 Cartridge No.	FFID Range	Shot Point Range
25	1373-1425	1377-1429
26	1426-1478	1430-1483
27	1479-1531	1483-1535
28	1532-1584	1536-1588
29	1585-1637	1589-1641
30	1638-1690	1642-1694

Exabyte Tape: LA08 Line: LARSE 01R JD 287 2110-2300Z

3480 Cartridge No.	FFID Range	Shot Point Range
31	1691-1743	1695-1747
32	1744-1796	1748-1800
33	1797-1849	1801-1853
34	1850-1902	1854-1906
35	1903-1955	1907-1959
36	1956-2008	1960-2012

Files 1810, 1827 may be bad

Exabyte Tape: LA09 Line: LARSE 01R JD 287-288 2301Z-?

3480 Cartridge No.	FFID Range	Shot Point Range
37	2009-2061	2013-2065
38	2062-2114	2066-2118
39	2115-2126	2119-2130
40	2127-2178	2131-2182
41	2179-2231	2183-2235
42	2232-2284	2236-2288

FFID 2129, 2130, 2131 may be bad.

Exabyte Tape: LA10 Line: LARSE 01R JD 288 0036Z-?

3480 Cartridge No.	FFID Range	Shot Point Range
43	2285-2337*	2289-2341*
44	2338-2390	2342-2394
45	2391-2404	2395-2408

***End of line (EOL) LARSE01R FFID 2307, 288/0044z**

Begin Line LARSE 01X

Exabyte Tape: LA11 Line: LARSE 01X JD 288 0135-0330Z

3480 Cartridge No.	FFID Range	Shot Point Range
45A	101-153	102-155
46	154-206	156-208
47	207-259	209-261
48	260-312	262-314
49	313-365	315-367
50	366-418	368-420

Shot 115 missed.

Exabyte Tape: LA12 Line: LARSE 01X JD 288 0330-0519Z

3480 Cartridge No.	FFID Range	Shot Point Range
51	419-471	421-473
52	472-524	474-526
53	525-577	527-579
54	578-630	580-632
55	631-683	633-685
56	684-736	686-738

Exabyte Tape: LA13 Line: LARSE 01X JD 288 0519-0630Z

3480 Cartridge No.	FFID Range	Shot Point Range
57	737-789	739-791
58	790-842	792-845
59	843-895	846-898
60	896-927*	899-930

***End of Line: LARSE 01X FFID 927, 288/0630z**

Start of Line: LARSE 01Y FFID 101 288/0630z

Exabyte Tape: LA14 Line: LARSE 01Y JD 288 0640-0844Z

3480 Cartridge No.	FFID Range	Shot Point Range
61	101-153	116-168
62	154-206	169-221
63	207-259	222-274
64	260-312	275-327
65	313-365	328-380
66	366-418	381-433

Exabyte Tape: LA15 Line: LARSE 01Y JD 288 0844-1037Z

3480 Cartridge No.	FFID Range	Shot Point Range
67	419-471	434-486
68	472-524	487-539
69	525-577	540-592
70	578-630	593-645
71	631-683	646-698
72	684-736	699-751

Exabyte Tape: LA16 Line: LARSE 01Y JD 188 1038Z-?

3480 Cartridge No.	FFID Range	Shot Point Range
73	737-789	752-804
74	790-842	805-857
75	843-895	858-910
76	896-948	911-963
77	949-1001	964-1016
78	1002-1044	1017-1059

END OF LINE LARSE 01Y FFID=1009 TIME=1212z JD288

TURN FFID= 110-1044 1227z JD288

START OF LINE LARSE TR1 FFID=101 TIME=1227z JD288

Exabyte Tape: LA17

3480 Cartridge No.	FFID Range	Shot Point Range
79	101-153	103-156
80	No Tape	No Tape
81	155-206	158-209
82	207-259	210-262
83	260-312	263-336
84	313-365	337-389

Tape popped out at end of line with no data on it -- Does not exist

3480 Cartridge No.	FFID Range	Shot Point Range
85	No Tape	No Tape

INTERRUPTION OF LARSE TR1 FFID=367 TIME=1428z JD288

Streamer ballast problems due to kelp on tail buoy. Problem fixed and near-offset part of streamer weighted.

RESUMPTION OF LARSE TR1 FFID= 101 TIME=1748z JD288

Exabyte Tape: LA18

3480 Cartridge No.	FFID Range	Shot Point Range
86	101-153	103-155
87	155-206	157-208
88	207-259	209-261
89	260-312	262-314
90	313-365	315-367
91	366-418	368-420

Exabyte Tape: LA19

3480 Cartridge No.	FFID Range	Shot Point Range
92	419-471	421-473
93	472-524	474-526
94	525-577	527-579
95	578-630	580-632
96	631-683	633-685
97	684-736	686-738
98	737-755	739-757

END OF LINE LARSE TR1 FFID=716 TIME=2119z JD288

START OF LINE LARSE 03 FFID=101 TIME=2146z JD288

Exabyte Tape: LA20 JD 288 2146-2240Z

3480 Cartridge No.	FFID Range	Shot Point Range
99	101-153	102-154
100	154-206	155-207
101	207-251	208-252

Abnormal termination 3480 Reel 101 FFID 251, retry unsuccessful, 9 shots not copied.
File 244 may be bad.

Exabyte Tape: LA21 JD 288 2241-2339Z

3480 Cartridge No.	FFID Range	Shot Point Range
102	260-312	261-313
103	313-365	314-366
104	366-418	367-419

File 329 may be bad.

Exabyte Tape: LA22 JD 288-289 2340-0035Z

3480 Cartridge No.	FFID Range	Shot Point Range
105	419-471	420-472
106	472-524	473-525
107	525-577	526-578

Bad file 442 skipped.

Exabyte Tape: LA23 JD 289 0035-0227Z

3480 Cartridge No.	FFID Range	Shot Point Range
108	578-630	579-631
109	631-683	632-684
110	684-736	685-737
111	737-789	738-790
112	790-842	791-843
113	843-895	844-896

File 797 may be bad.

Exabyte Tape: LA24 JD 289 0227-0419Z

3480 Cartridge No.	FFID Range	Shot Point Range
114	896-948	897-949
115	949-1001	950-1002
116	1002-1054	1003-1055
117	1055-1107	1056-1108
118	1108-1160	1109-1187
119	1161-1213	1188-1241

Exabyte Tape: LA25 JD 289 0419-0607Z

3480 Cartridge No.	FFID Range	Shot Point Range
120	1214-1266	1242-1294
121	1267-1319	1295-1347
122	1320-1372	1348-1400
123	1373-1425	1401-1453
124	1426-1478	1454-1506

Exabyte Tape: LA25A JD 289 0550-0607Z

3480 Cartridge No.	FFID Range	Shot Point Range
12r	1479-1508	1507-1536

FFID 1508 traces 1-137 (should be 1-180); FFID 1509 traces 1-1 (bad record). FFID 1508-1509 skipped - bad. Abnormal termination tape 125. FFID 1509 lost; files 1510-1531 not copied to tape

Exabyte Tape: LA26 JD 289 0608-0801Z

start record of channels 1-160 only

3480 Cartridge No.	FFID Range	Shot Point Range
126	1532-1584	1560-1612
127	1585-1637	1613-1665
128	1638-1690	1666-1718
129	1691-1743	1719-1771
130	1744-1796	1772-1824
131	1797-1849	1825-1877

Exabyte Tape: LA27 JD 289 0802-0959Z

3480 Cartridge No.	FFID Range	Shot Point Range
132	1850-1902	1878-1930
133	1903-1955	1931-1983
134	1956-2008	1984-2036
135	2009-2061	2037-2093
136	2062-2114	2094-2146
137	2115-2167	2147-2199

Exabyte Tape: LA28 JD 289 1000-1155Z

3480 Cartridge No.	FFID Range	Shot Point Range
138	2168-2220	2200-2252
139	2221-2273	2253-2305
140	2274-2326	2306-2359
141	2327-2379	2360-2412
142	2380-2432	2413-2465
143	2433-2479	2466-2512

End of Line LARSE 03 on 3480 Reel 143, FFID 2479, 289/1155

Start of Line LARSE 03R

Exabyte Tape: LA29 JD 289 1212-1424Z

3480 Cartridge No.	FFID Range	Shot Point Range
144	101-153	102-154
145	154-206	155-207
146	207-259	208-260
147	260-312	261-313
148	313-365	314-366
149	366-418	367-419
150	419-471	420-472

FFID 348-365 were not transcribed from 3480 Cartridge No. 148 because of read error. Exabyte Tape LA29A JD 289 will contain FFID 348-365 if possible to read.

Exabyte Tape: LA30 JD 289 1424-1631Z

3480 Cartridge No.	FFID Range	Shot Point Range
151	472-524	473-525
152	525-577	526-528
153	578-630	579-631
154	631-683	632-684
155	684-736	685-737
156	737-789	738-790
157	790-842	791-843

Exabyte Tape: LA31 JD 289 1632-1840Z

3480 Cartridge No.	FFID Range	Shot Point Range
158	843-895	844-896
159	896-948	897-949
162	951-1002	952-1003
163	1003-1055	1004-1056
164	1056-1108	1057-1109
165	1109-1161	1110-1162
166	1162-1214	1163-1215

3480 Cartridge Nos. 160 and 161 do not exist. Files 949-951 lost. SP 950-951 lost.
3480 Cartridge No. 162 starts with file 952. Cartridge did not get changed.

Exabyte Tape: LA32 JD 289 1840-2024Z

3480 Cartridge No.	FFID Range	Shot Point Range
167	1215-1267	1216-1268
168	1268-1320	1269-1321
169	1321-1373	1322-1374
170	1374-1426	1375-1427
171	1427-1479	1428-1480
172	1480-1528	1481-1529

Start channels 1-180 per FFID. Abnormal termination 3480 Cartridge No. 172 FFID 1528, 3 files lost; shots 1530-1533 lost.

Exabyte Tape: LA33 JD 289 2024-2216Z

3480 Cartridge No.	FFID Range	Shot Point Range
173	1533-1585	1534-1601
174	1586-1638	1602-1655
175	1639-1691	1656-1708
176	1692-1744	1709-1761
177	1745-1797	1762-1814
178	1798-1850	1815-1867

Shots lost because firing interval became too short = 1563, 1565, 1567, 1569, 1571, 1573, 1575, 1577, 1579, 1581, 1583, 1585, 1587, 1589, 1591.

Exabyte Tape: LA34 JD 289-290 2216-0009Z. **File 2036 may be bad.**

3480 Cartridge No.	FFID Range	Shot Point Range
179	1851-1903	1868-1920
180	1904-1956	1921-1973
181	1957-2009	1974-2026
182	2010-2062	2027-2079
183	2063-2115	2080-2132
184	2116-2168	2133-2185

Exabyte Tape: LA35 JD 290 0010-0144Z

3480 Cartridge No.	FFID Range	Shot Point Range
185	2169-2221	2186-2238
186	2222-2274	2239-2291
187	2275-2327	2292-2344
188	2328-2380	2345-2397
189	2381-2433	2398-2450

Sonobouy #2 on 3480 Cartridge Nos. 186,187,188,189,190

Exabyte Tape: LA36 JD 290 0144-0229Z

3480 Cartridge No.	FFID Range	Shot Point Range
190	2434-2486	2451-2503
191	2487-2539	2504-2556
192	2540-2551	2557-2568

End of Line LARSE 03R at FFID 2551

Start of Line LARSE TR2

Exabyte Tape: LA37

3480 Cartridge No.	FFID Range	Shot Point Range
193	101-153	102-154
194	154-206	155-207
195	207-259	208-260
196	260-274	261-275

Exabyte Tape: LA38

3480 Cartridge No.	FFID Range	Shot Point Range
197	101-153	299-351
198	154-206	352-404
199	207-259	405-457
200	260-295	458-493

End of Line LARSE TR2

Beginning of Line LARSE 02 (outbound leg)
Streamer straight at shot 167

Exabyte Tape: LA39 JD290 0551-0751z

3480 Cartridge No.	FFID Range	Shot Point Range
201	102-153	105-156
203	155-206	158-209
204	207-259	210-262
205	260-312	263-315
206	313-365	316-368
207	366-418	369-421

**No 3408 Cartridge No. 202; FFID 157, 158, 187, 188 are bad.

Exabyte Tape: LA40 JD290 0752-0932z

3480 Cartridge No.	FFID Range	Shot Point Range
208	419-471	422-474
209	472-524	475-527
210	525-577	528-580
211	578-630	581-633
212	631-683	634-686
213	684-736	687-739

Exabyte Tape: LA41 JD290 0932-1149z

3480 Cartridge No.	FFID Range	Shot Point Range
214	737-789	740-792
215	790-842	793-845

Exabyte Tape: LA41A

3480 Cartridge No.	FFID Range	Shot Point Range
216	843-895	846-898
217	896-948	899-951
218	949-1001	952-1004
219	1002-1054	1005-1057

File 876 skipped - bad

Exabyte Tape: LA42 JD290 1149-1351z

3480 Cartridge No.	FFID Range	Shot Point Range
220	1055-1107	1058-1111
221	1108-1160	1112-1164
222	1161-1213	1165-1217
223	1214-1266	1218-1270
224	1267-1319	1271-1323
225	1320-1372	1324-1376

FFID 1063 may be bad

Exabyte Tape: LA43 JD290 1351-1600z

3480 Cartridge No.	FFID Range	Shot Point Range
226	1373-1425	1377-1429
227	1426-1478	1430-1482
228	1479-1531	1483-1535
229	1532-1584	1536-1588
230	1585-1637	1589-1641
231	1638-1690	1642-1694

Exabyte Tape: LA44 JD290 1601-1815z

3480 Cartridge No.	FFID Range	Shot Point Range
232	1691-1743	1695-1747
233	1744-1796	1748-1801
234	1797-1849	1802-1854
235	1850-1902	1855-1907
236	1903-1955	1908-1960
237	1956-2008	1961-2013

Shot 1787 not recorded

Exabyte Tape: LA45 JD290 1816-2028z

3480 Cartridge No.	FFID Range	Shot Point Range
238	2009-2061	2014-2066
239	2062-2114	2067-2119
240	2115-2167	2120-2172
241	2168-2220	2173-2225
242	2221-2273	2226-2278
243	2274-2326	2279-2331

Exabyte Tape: LA46 JD290 2029-2234z

3480 Cartridge No.	FFID Range	Shot Point Range
244	2327-2379	2332-2384
245	2380-2432	2385-2437
246	2433-2485	2438-2490
247	2486-2538	2491-2543
248	2539-2591	2544-2596
249	2592-2644	2597-2649

Exabyte Tape: LA47 JD290-291 2234-0023

3480 Cartridge No.	FFID Range	Shot Point Range
250	2645-2697	2650-2702
251	2698-2750	2703-2755
252	2751-2803	2756-2808
253	2804-2856	2809-2961
254	2857-2909	2862-2914
255	2910-2962	2915-2967

FFID 2919 may be bad

Exabyte Tape: LA48 JD291 0023-0147

3480 Cartridge No.	FFID Range	Shot Point Range
256	2963-3015	2968-3020
257	3016-3068	3021-3073
258	3069-3121	3074-3126
259	3122-3174	3127-3179
260	3175-3197	3180-3202

Start turn at FFID 3095, 0108z, shotpoints 3023,3024,3026,3027 had errors

Start of Line LARSE 02R Shot Interval = 90 secs (Not a useful MCS Pass)

Exabyte Tape: LA49 JD291 0148-0952z

3480 Cartridge No.	FFID Range	Shot Point Range
261	101-153	102-154
262	154-206	155-207
263	207-259	208-260
264	260-312	261-313
265	313-365	314-366
266	366-418	367-419
267	419-471	420-472

Exabyte Tape: LA50 JD291 0953-1955z

3480 Cartridge No.	FFID Range	Shot Point Range
268	472-524	473-525
269	525-577	526-578
270	578-630	579-631
271	631-683	632-684
272	684-736	685-737
273	737-789	738-790
274	790-821	791-822

End of Line 02R FFID 821, 291/1955

Start Line LARSE 02X

Exabyte Tape: LA51 J.D. 291 2103z-2249z

3480 Cartridge No.	FFID Range	Shot Point Range
275	101-153	104-156
276	154-206	157-209
277	207-259	210-262
278	260-312	263-315
279	313-365	316-368
280	366-418	369-421

Exabyte Tape: LA52 J.D. 291-292 2249z-0035z

3480 Cartridge No.	FFID Range	Shot Point Range
281	419-471	422-474
282	472-524	475-527
283	525-577	528-580
284	578-630	581-633
285	631-664	634-667
286	684-736	688-740

I/O error 3480 Cartridge No. 285, FFID 665-683 not copied, SP 678 lost. Is 3480 Cartridge No. 286 here?

Exabyte Tape: LA52A **not yet copied** 0000z-0017z

3480 Cartridge No.	FFID Range	Shot Point Range
285	631-683	634-688

Error at file 664; not able to read beyond yet; FFID 664-683 missing on 8mm.

Exabyte Tape: LA53 J.D. 292 0035z-0203z

3480 Cartridge No.	FFID Range	Shot Point Range
287	737-789	741-793
288	790-842	794-846
289	843-895	847-899
290	896-948	900-952
291	949-978	953-982

I/O error, last good file=978 3480 Cartridge No. 291; unable to read beyond FFID 978.

Exabyte Tape: LA53A J.D. 292 0204z-0221z

3480 Cartridge No.	FFID Range	Shot Point Range
292	1002-1054	1006-1058

Exabyte Tape: LA53B **not yet copied** 0146z-0203z

3480 Cartridge No.	FFID Range	Shot Point Range
291	949-1001	953-1005

Error at FFID 978/979; unable to read beyond yet; FFID 979-1001 still not on 8mm.

Exabyte Tape: LA54 J.D. 292 0222z-0359z

3480 Cartridge No.	FFID Range	Shot Point Range
293	1055-1107	1059-1111
294	1108-1160	1112-1164
295	1161-1189	1165-1195
296	1190-1241	1196-1247
297	1242-1294	1248-1300
298	1295-1345	1301-1351

End of Line LARSE 02X

Beginning of Line LARSE 02Y

Exabyte Tape: LA55

3480 Cartridge No.	FFID Range	Shot Point Range
299	101-153	102-154
301	155-206	156-207
302	207-259	208-260
303	260-312	261-313
304	313-365	314-366
305	366-418	367-419

Tape-label error -- No label for 3480 Cartridge No. 300 printed.

Exabyte Tape: LA56

3480 Cartridge No.	FFID Range	Shot Point Range
306	419-471	420-472
307	472-524	473-525
308	525-577	526-578
309	578-630	579-631
310	631-683	632-684
311	684-736	685-737

Exabyte Tape: LA57

3480 Cartridge No.	FFID Range	Shot Point Range
312	737-789	738-790
313	790-842	791-843
314	843-895	844-896
315	896-948	897-949
316	949-1001	950-1002
317	1002-1054	1003-1055

Exabyte Tape: LA58

3480 Cartridge No.	FFID Range	Shot Point Range
318	1055-1107	1056-1108
319	1108-1160	1109-1161
320	1161-1213	1162-1214
321	1214-1266	1215-1267
322	1267-1319	1268-1320
323	1320-1372	1321-1373

Exabyte Tape: LA59

3480 Cartridge No.	FFID Range	Shot Point Range
324	1373-1425	1374-1426
325	1426-1478	1427-1479
326	1479-1531	1480-1533
327	1532-1584	1534-1586
328	1585-1616	1587-1618

END OF LINE LARSE 02Y at SP 1618, File 1616

Start Of Line LARSE 02Z 3480 Reel 329

Exabyte Tape: LA60

3480 Cartridge No.	FFID Range	Shot Point Range
329	101-153	122-174
330	154-206	175-227
331	207-259	228-280
332	260-312	281-333
333	313-365	334-386
334	366-418	387-439

Exabyte Tape: LA61

3480 Cartridge No.	FFID Range	Shot Point Range
335	419-471	440-492
336	472-524	493-545
337	525-577	546-598
338	578-630	599-651
339	631-683	652-704
340	684-736	705-757

Exabyte Tape: LA62

3480 Cartridge No.	FFID Range	Shot Point Range
341	737-789	758-810
342	790-842	811-863

End of Line LARSE 02Z

Beginning of Line LARSE TR3

Exabyte Tape: LA63

3480 Cartridge No.	FFID Range	Shot Point Range
343	844-895	106-157
344	896-948	158-210
345	949-1001	211-263
346	1002-1054	264-316
347	1055-1107	317-369
348	1108-1160	370-422

Exabyte Tape: LA64

3480 Cartridge No.	FFID Range	Shot Point Range
349	1161-1213	423-475
350	1214-1266	476-528
351	1267-1319	529-581
352	1320-1372	582-634
353	1373-1425	635-687
354	1426-1478	688-740

Exabyte Tape: LA65

3480 Cartridge No.	FFID Range	Shot Point Range
355	1479-1531	741-793
356	1532-1584	794-846
357	1585-1637	847-899
358	1638-1690	900-925
359	1691-1743	953-1005
360	1744-1796	1006-1058

Exabyte Tape: LA66 J.D.

3480 Cartridge No.	FFID Range	Shot Point Range
361	1797-1849	1059-1111
362	1850-1873	1112-1135

End Line LARSE TR3 file1873 SP 1135

Start LARSE 01A

Exabyte Tape: LA67A J.D. 292-293 2352z-0137z

3480 Cartridge No.	FFID Range	Shot Point Range
363	101-153	103-155
NO 3480 REEL 364	**NO 3480 REEL 364**	**NO 3480 REEL 364**
365	155-206	157-208
366	207-259	209-261
367	260-312	262-314
368	313-365	315-367
369	366-418	368-420

SP 156 lost; FFID 269/270, 302/303 may be bad

Exabyte Tape: LA67 J.D. 293 0138z-0323z

3480 Cartridge No.	FFID Range	Shot Point Range
370	419-471	421-473
371	472-524	474-526
372	525-577	527-579
373	578-630	580-632
374	631-683	633-685
375	684-736	686-738

Exabyte Tape: LA68 J.D. 293 0324z-0434z

3480 Cartridge No.	FFID Range	Shot Point Range
376	737-789	739-791
377	790-842	792-844
378	843-895	845-897
379	896-948	898-950

Exabyte Tape: LA69 J.D. 293 0434z-0558z

3480 Cartridge No.	FFID Range	Shot Point Range
380	949-1001	951-1003
381	1002-1054	1004-1056
382	1055-1107	1957-1109
383	1108-1160	1110-1162
384	1161-1199	1163-1201

End of Line LARSE 01A

Start of Line LARSE 01B

Exabyte Tape: LA70 J.D. 293 0641z-0827z

3480 Cartridge No.	FFID Range	Shot Point Range
385	101-153	102-154
386	154-206	155-207
387	207-259	208-260
388	260-312	261-313
389	313-365	314-366
390	366-418	367-419

Exabyte Tape: LA71 J.D. 293 0827z-1013z

3480 Cartridge No.	FFID Range	Shot Point Range
391	419-471	420-472
392	472-524	473-525
393	525-577	526-578
394	578-630	579-631
395	631-683	632-684
396	684-736	685-737

Exabyte Tape: LA72 J.D. 293 1013z-1201z

3480 Cartridge No.	FFID Range	Shot Point Range
397	737-789	738-797
398	790-842	798-850
399	843-895	851-903
400	896-948	904-956
401	949-1001	957-1009
402	1002-1054	1010-1062

SP 745, 746, 753-757 lost

Exabyte Tape: LA73 J.D. 293 1201z-1355z

3480 Cartridge No.	FFID Range	Shot Point Range
403	1055-1107	1063-1115
404	1109-1160	1117-1168
405	1161-1213	1169-1221
406	1214-1266	1222-1274
407	1267-1319	1275-1327
408	1320-1372	1328-1380
409	1373-1396	1381-1404

SP 1116 lost

End of Line LARSE 01B

Start of Line LARSE 04

Exabyte Tape: LA74 J.D. 293 1443z-1612z

3480 Cartridge No.	FFID Range	Shot Point Range
410	101-153	101-153
411	154-206	154-206
412	207-259	207-259
413	260-312	260-312
414	313-365	313-365
415	366-368	366-367

Line terminated because chase boat caught in streamer. Add data to end of LARSE 01B.

End of Line LARSE 04

Start of Line LARSE-06

Exabyte Tape: LA75 J.D. 293 1836z-2021z

3480 Cartridge No.	FFID Range	Shot Point Range
416	101-153	102-154
417	154-206	155-207
418	209-259	210-260
419	260-312	261-313
420	313-365	314-366
421	366-418	367-419

FFID 133 bad, not copied?; files 207, 208 lost.

Exabyte Tape: LA76 J.D. 293 2202z-2208z

3480 Cartridge No.	FFID Range	Shot Point Range
422	419-471	420-472
423	472-524	473-525
424	525-577	526-578
425	578-630	579-631
426	631-683	632-685
427	684-736	686-738

Start turn at JD 293 2128z about FFID 630, end turn at FFID 683, 293/2147 (streamer not straight).
SP 606 bad?, SP 637 lost.

Exabyte Tape: LA77 J.D. 293 2209z-2354z

3480 Cartridge No.	FFID Range	Shot Point Range
428	737-789	739-791
429	790-842	792-844
430	843-895	845-897
431	896-948	898-950
432	949-1001	951-1003
433	1002-1054	1004-1056

Exabyte Tape: LA78 J.D. 293-294 2354z-0140z

3480 Cartridge No.	FFID Range	Shot Point Range
434	1055-1107	1057-1110
435	1108-1160	1111-1163
436	1161-1213	1164-1216
437	1214-1266	1217-1269
438	1268-1319	1271-1322
439	1320-1372	1323-1375

SP 1065 lost; file 1267 lost; SP 1278 bad?

Exabyte Tape: LA79 J.D. 294 0141z-0327z

3480 Cartridge No.	FFID Range	Shot Point Range
440	1373-1425	1376-1428
441	1426-1478	1429-1481
442	1479-1531	1482-1534
443	1532-1584	1535-1587
444	1585-1637	1588-1640

445	1638-1690	1641-1693

Exabyte Tape: LA80 J.D. 294 0327z-0430z

3480 Cartridge No.	FFID Range	Shot Point Range
446	1691-1743	1694-1746
447	1744-1796	1747-1799
448	1797-1814	1800-1819
449	1816-1866	1821-1871
450	1867-1878	1872-1883

No FFID 1815

End of Line LARSE -06

End of Ewing Cruise

APPENDIX 4.

DATA REDUCTION CRUISE SUMMARY

EW-9415

LARSE Experiment:
Seismic Survey offshore Los Angeles/Northridge

Long Beach, CA - San Diego, CA , U.S.A.

10/03/94 (JD-286) -- 10/10/94 (JD-294)

CHIEF SCIENTISTS:

Thomas Brocher, USGS

(brocher@andreas.wr.usgs.gov)

SCIENCE OFFICER:

Bruce A. Francis (baf@ldeo.columbia.edu)

DATA REDUCTION:

Stefanus Budhypramono (dared@ldeo.columbia.edu)

R/V MAURICE EWING

SCIENCE OVERVIEW:

This project involved onshore-offshore seismic profiling of the crustal structure in the greater Los Angeles area, to identify and better understand the earthquake hazards of the region. The Ewing served as a source of seismic energy for both multichannel seismic reflection profiling as well as for an dense array of land stations. Three main lines were run: one through the Sierra Madre epicenter and Los Angeles Basin, one through the epicenter of the Northridge earthquake, and a third trending NE-SW through the Los Angeles basin.

TRUE TIME CLOCK:

Instrument: *Kinemetric/TrueTime Division Model GPS-DC GPS Synchronized Clock*
Logging: 1 minute intervals
NOTE: The True Time clock is used to adjust the CPU clock of the logging computer. The logging computer captures the continuous time records from the clock and provides these as a service to the rest of the network via a UDP broadcast. This enables the computers on the network to adjust their CPU times to UTC time.

DAY	TIME	COMMENTS
286	1530	start of cruise, started logging/processing
294	1600	end of cruise; stopped logging/processing

SPEED AND HEADING:

Instrument: *Furuno CI-30 2-axis Doppler speed log, Sperry MK-27 gyro*
Logging: 3 second intervals
Checking: visual check of plot of data
Smoothing: mean value of all good values within the same minute

DAY	TIME	COMMENTS
286	1530	start of cruise; started logging/processing
294	1600	end of cruise ; stopped logging/processing

TRANSIT SATELLITE FIXES:

Instrument: *Magnavox MX-1107RS dual frequency Transit satellite receiver*
Logging: all fixes
Checking: reject receiver flagged fixes, fixes with high drifts in navigation

DAY	TIME	COMMENTS
286	1530	start of cruise; started logging/processing
294	1600	end of cruise ; stopped logging/processing

GPS SATELLITE FIXES:

Instrument: *Magnavox MX-4200 Global Positioning System receiver*
Logging: 10 second intervals on GPS MX-4200 #1
10 second intervals on GPS MX-4200 #2
Checking:
minimum number of SATs: 3
dilution of precision maximum: north = 4.0, east = 4.0
carrier signal-noise ratio minimum: 35.0
standard deviation maximum: north =4.0, east = 4.0
time step maximum: 3
speed maximum: 30.0
compared GPS speed and course with Furuno smooth speed and heading
compared positions with Transit-Furuno navigation
reject fixes with high drifts in navigation
reject fixes producing Eotvos correction errors in gravity larger than 5 mGals
Interpolation: interpolated positions at 00, 30 seconds of each minute
Smoothing: smoothed interpolated positions with 9 or 41 point running average depending on the quality of GPS data and the sea state.

Note: The GPS data has a sinusoidal wave which is assumed to come from some degrading of the GPS quality for civilian usage. This wave seems to vary in period and shapes and is not a perfect sine curve. The periods are less than 20 minutes. The amplitu des tend to vary over 24 hours and the sea state condition. This degrading produces a false ship's track in real-time navigation and introduces extreme errors, up to 10 mGals, in the Eotvos correction for the gravity. As this problem varies in its intensit y depending on the sea state and GPS data quality itself, several methods of data reduction has been developed to achieve the best possible navigation.

1. A 9 point (4 minutes) GPS smoothing
2. A 9 point (4 minutes) GPS smoothing, decimated to a 20 min. fixes
3. A 41 point (20 minutes) GPS smoothing
4. A 41 point (20 minutes) GPS smoothing, decimated to a 20 min. fixes

It should be noted that the use of 41 point smoothing causes the turn to "widens". Hence, in the instances where a 41 point smoothing is called for, the GPS data at and around the turn are decimated to 20 minutes.

Throughout this cruise, a 9 point (4 minutes) GPS smoothing, decimated to a 20 min. fixes were used to produce final navigation data.

DAY	TIME	COMMENTS
286	1530	started data logging/processing
294	1600	end of cruise ; stopped data logging/processing

NAVIGATION:

A "1 minute navigation" is produced from the above sources, which in this cruise is a 9 point (4 minutes) GPS smoothing, decimated to a 20 min. fixes. Acceptable fixes are merged at 1 per minute with priority given to GPS. The smooth speed and heading dat a is used to fill any gaps of 2 minutes or longer between fixes by computing 1 minute DR'ed positions corrected for set and drift between fixes. The DR'ed positions are produced at 00 seconds of each minute.

Chief scientist's final data: 1 minute navigation.

FORMAT: n.ddd

    yy+ddd:hh:mm:ss.mmm N 12 12.1234 E 123 12.1234 id 123.1 12.1
    yr. day   time   lat.   lon   id set drift

Lamont database: 1 minute navigation, in MGG format.

DAY	TIME	COMMENTS
286	1530	started data processing
294	1600	end of cruise ; stopped data processing

<u>SEA TEMPERATURE</u>:

Instrument: *Omega DP10 Series*
Logging: 1 minute intervals
Checking: none
Smoothing: none

Chief scientist's final data: one minute data, merged with navigation.
Lamont database: one minute data, merged with navigation.

FORMAT: ct.nddd
yy+ddd:hh:mm:ss:mmm N 12 12.1234 E 123.1234 26.3
    yr day   time   lat   lon   sea_temp (in ^{o}C)

DAY	TIME	COMMENTS
286	1530	started data processing
294	1600	end of cruise ; stopped data processing

<u>MAGNETIC</u>:

Instrument: *Varian V75 magnetometer*
Logging: 6 second intervals
Checking: visual check of plot of data
Reference field: International Geomagnetic Reference Field 1990 (*IGRF 1990*) model of the main field at 1985.0 and a predictive model of the secular variation for adjusting to dates between 1990.0 and 1995.0.
Residual field: Applied by bi-linear interpolation across a 1 degree square.

Chief Scientist's final data: final calibrated and cleaned data.

FORMAT: mg.nddd

    yr+ddd:hh:mm:ss.mmm N 12 12.1234 E 123 12.1234 41200.8 -367.1
    yr. day   time   lat   lon   total_intensity anomaly

Lamont Database: interpolated total intensity value at 00 second of each minute

NOTE:

DAY	TIME	COMMENTS
286	2000	started logging
291	1624-2359	maggie off the water; no data
292	0000-0533	maggie off the water; no data
292	1710-2003	bad maggie data ; data removed
294	0440	maggie off the water; end of logging

ADCP (Acoustic Doppler Current Profilers):

Instrument: *RD Instrument RD-VM Model ADCP*
Logging: logging is done by a 386 IBM PC compatible
Checking: none
Smoothing: none

Chief scientist's final data: processed data file format and navigation data file format.
Lamont database: processed data file format and navigation data file format.

FORMAT: Refer to Transect User's Manual for Narrowband ADCP Appendix B.

DAY	TIME	COMMENTS
286	1530	beginning of the cruise ; started logging/processing
294	1600	end of cruise; stopped logging/processing

BATHYMETRY:

Instrument: *Krupp Atlas Hydrosweep Center Beam*
Logging: At each ping of *Hydrosweep*, data is being broadcasted real time to the network, which is received by data logger. The logger computer then extracted the center beam depth.
Checking: Visual checking aided by graphic editor to remove major spikes.

Chief scientist's final data:
final calibrated and cleaned center beam data, two nearest point to the minute interpolated to even minute.
Merged with final navigation.
Depth is in meters.

FORMAT: hb.nddd
yy+ddd:hh:mm:ss:mmm N 12 12.1234 E 123 12.1234 2222.0
yr. day time lat. lon depth_in_meters

Lamont database:
final calibrated and cleaned data, interpolated to even minute.
Merged with final navigation. MGG format.
Depth is in fathoms.

NOTE: At the beginning of EW-9414, a problem was found with the swath data coming out of the Hydrosweep to the logging computer "olive". An "Unknown data type" error message appeared in "get_hs" log file. Upon closer inspection, this message was generated because the data coming out of the serial line seems to be mangled if it happens to coincide with the pop of the seismic guns. It has yet to be determined whether this was caused by the shock of the guns, or it was an acoustic-interference problem.

DAY	TIME	COMMENTS
286	1520	started logging/processing
291	0104-0542	Hydrosweep was shut off to trace missing data problem
291	0837-0856	Hydrosweep was shut off to trace missing data problem

294	1600	end of cruise; stopped logging/processing

SHOT TIME & GUN DEPTH:

IInstrument: *L-DEO Time Tagger and GunDepth Interface*
Logging: Shot Time from the Time tagger. Gun Depth from Gun Depth Interface

FORMAT: ts.nddd (shot time)

```
        94+173:00:04:04.333 000172 N 40 56.5884 W 125 42.6913 mcs-6a
        SHOT TIME          shotnum    lat                  lon           line name
```

FORMAT: dg.rddd (gun depth)

```
        94+173:00:04:04.333 13 13 13 13 13 13 13 13 ....
                SHOT TIME          GUN DEPTH
```

Note: A '-' sign following the year means that shottime was not received in time. A CPU timetag is placed instead. This sometimes happens at the beginning of the line when the computer and the DMS-2000 are trying to get in sync with each other. No gun was fired, and no data is recorded to the tape.

JDAY & TIME	Shot Number	LINE NAME	COMMENTS
286:18:49:17-287:05:41:37	0101-0753	LA01	shot-by-dist 50m
287:11:55:42-288:01:24:01	0105-2414	LARSE01R	shot-by-dist 50m
288:01:28:30-288:06:32:37	0101-0935	LARSE01X	shot-by-dist 50m
288:06:32:56-288:12:35:17	0101-1068	LARSE01Y	shot-by-dist 50m
288:12:36:27-288:21:44:45	0101-0783	LARSETR1	shot-by-dist 50m
288:21:45:16-289:12:10:24	0101-2546	LARSE03	shot-by-dist 50m
289:12:11:30-290:02:37:25	0101-2587	LARSE03R	shot-by-dist 50m
290:02:38:46-290:04:59:09	0101-0494	LARSETR2	shot-by-dist 50m
290:05:17:27-291:02:54:01	0101-3215	LARSE02	shot-by-dist 50m
291:01:54:58-291:19:56:51	0101-0822	LARSE02R	shot-by-time 90 secs.
291:20:52:55-292:04:04:19	0101-1369	LARSE02X	shot-by-dist 50m
292:04:05:21-292:12:31:41	0101-1619	LARSE02Y	shot-by-dist 50m
292:13:29:27-292:17:50:16	0101-0883	LARSE02Z	shot-by-dist 50m
292:17:51:16-292:23:49:10	0101-1174	LARSETR3	shot-by-dist 50m
292:23:51:10-293:06:40:04	0101-1327	LARSE01A	shot-by-dist 50m
293:06:40:41-293:13:56:16	0101-1407	LARSE01B	shot-by-dist 50m
293:14:00:13-293:14:43:08	0101-0126	LARSE04	shot-by-dist 50m
293:14:43:08-293:16:44:02	0101-0462	MARSE04	shot-by-dist 50m
293:18:35:45-294:04:31:30	0101-1885	LARSE06	shot-by-dist 50m

Partial CO2:

Instrument: *L-DEO PCO2 Group PCO2 Analysis Instrument*
Logging: as is.
Checking: none

Chief scientist's final data: none.
Lamont database: merged data with final navigation.

FORMAT:

94+036:22:35:00.000 S 21 31.0624 W 31 27.2926 94036.9360
Yr Day Hr Mn Second Lat Lon YrDay.frac

2033.8 2033.8 1014.0 34.64 33.8 419.9 404.5 28.41 Equil 28.2
IR_1 IR_2 Baro CellT Flow VCO2 pCO2 Eq_T Type SeaT

YrDay.frac = Time of analysis

IR_1 = CO2 signal (mv)

IR_2 = CO2 signal (mv)

Baro = IR Cell pressure (mbar)

CellT = IR Cell temperature (deg C)

Flow = Sample/Standard gas flow rate through IR cell (ml/mn)

VCO2 = Concentration of CO2 in dry gas sample (preliminary value) (ppm)

pCO2 = Partial pressure of CO2 in water-saturated air at temperature of equilibration (uatm); (or residual of 2nd order fit if standard (calibration) gas)

Eq_T = Equilibration temperature (deg C)

Type = Type of analysis [Equil= equilibrated seawater, Airi= atmospheric air, Stdn= calibration gas]

SeaT = Sea Surface Temperature, measured using thermistor on ship's keel (depth= ?? meters) (deg C)

DAY	TIME	COMMENTS
286	1530	beginning of the cruise ; started logging/processing
294	1600	end of cruise ; stopped logging

WEATHER STATION:

Instrument: *R.M/. Young Precision Meteorological Instruments 26700 Series*
Logging: 1 minute interval
Checking: none

Chief scientist's final data: as is.
Lamont database: as is.

FORMAT: wx.rddd
Port bird is bird #1; starboard bird is bird #2.

94+022:00:00:00.244 9.3 15.4 13.2 21.1 271 261
date time wsi1 wss1 wsm1 wsx1 wdc1 wds1

6 12.6 15.9 15.6 20.7 261 253 6 66.7 66.7
wdm1 wsi2 wss2 wsm2 wsx2 wdc2 wds2 wdm2 tcur tavg

66.5 67.0 66 58 68 1016.8
tmin tmax rh rhn rhx baro

wsi1/2 = wind speed, instantaneous, bird #1/#2
wss1/2 = wind speed, 60 second average, bird #1/#2
wsm1/2 = wind speed, 60 minute average, bird #1/#2
wsx1/2 = wind speed, 60 minute maximum, bird #1/#2
wdc1/2 = wind direction, current, bird #1/#2
wds1/2 = wind direction, 60 second average, bird #1/#2
wdm1/2 = wind direction, 60 minute average, bird #1/#2

tcur = temperature, current
tavg = temperature, 60 minute average
tmin = temperature, 60 minute minimun
tmax = temperature, 60 minute maximum

rh = relative humidity
rhn = relative humidity, 60 minute minimum
rhx = relative humidity, 60 minute maximum

baro = barometric pressure

DAY	TIME	COMMENTS
286	1530	beginning of the cruise ; started logging
294	1600	end of cruise; stopped logging

KSS-30 GRAVITY:

Instrument: *Bodenseewerke KSS-30 marine gravity meter*
Logging: 6 second intervals
Merge with navigation: calculate Eotvos correction and Free Air Anomaly.
Checking: Visual check of plot of data to determine satisfactory Eotvos corrections, reject spikes of data at turns.
Velocity smoothing: 5 point running average throughout the cruise
Processing:

The KSS-30 times tag is first adjusted for the filtering delay. For "Seastate" setting 2, the delay due to filtering is 75 seconds. Thus75 seconds are subtracted from the time tag and a new, adjusted time is computed.

A smooth KSS-30 gravity mgal value at one minute interval is calculated on 00 second of the minute by computing the unweighted mean values from the raw values that lie between +- 30 seconds of 00 seconds of the minute.

Calculation:

eotvos_corr = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel
corrected_grv = raw_grv + eotvos_corr - drift - dc_shift
faa = corrected_grv - theoretical_grv

Chief scientist's final data: Observed, Eotvos, Free Air Anomaly value at 00 seconds of each minute.

1980 theoretical gravity formula:

$$Y_0 = 978.0327 \times (1 + .0053024 \times \sin(Q) \times \sin(Q) - .0000058 \times \sin(2 \times Q) \times \sin(2 \times Q))$$

FORMAT: vk.nddd
yy+ddd:hh:mm:ss.mmm N 10 20.1234 W 120 23.1234 1980 77.1

yr. day time lat. lon. theog FAA
979317.5 64.1 1.5 10.2 -1.7 9.7 -1.6 9.8
raw_grav eotvos drift dc_shift raw_vel smo_vel

Lamont database: Free Air Anomaly value at 00 seconds of each minute.
1930 International gravity formula.

Note:

A '-' sign after the year in the record signifies a flagged record due to turn.

As a result of the discussion among the MG&G group, Lamont Data Reduction will use Port's Gravity Referenced Value without Potsdam correction for gravity data sent to MG&G data base at Lamont.
Further discussion also revealed that *1980 theoretical gravity formula* has incorporated Potsdam correction in its formula.

At the start of the cruise, KSS-30 platform was found turned off. As a result, there is no data until the start of JD 164.

DAY	TIME	COMMENTS
286	1530	started data processing
294	1600	end of cruise ; stopped data processing

BGM-3 GRAVITY:

Instrument: *Bell Aerospace BGM-3 marine gravity meter*
Logging: 1 second intervals
Merge with navigation: calculate Eotvos correction and Free Air Anomaly.
Checking: Visual check of plot of data to determine satisfactory Eotvos corrections, reject spikes of data at turns.
Velocity smoothing: 5 point running average throughout the cruise.
Processing:

Since current BGM-3 output has double counts every few minutes the following scheme has been implemented until the hardware and interface code has been fixed:

(1) Run a 1 minute Gaussian filter through the data. This will narrow the output spikes and make them stand out better. Output interval has been hard-wired to every 15 seconds.

(2) Pass the output through filter1d (see gmtsystem) using -FG480 (an 8 minute Gaussian filter with robust option, i.e., ignore "outlier" points (i.e. the spikes).

Calculation:

eotvos_corr = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel
corrected_grv = raw_grv + eotvos_corr - drift - dc_shift
faa = corrected_grv - theoretical_grv

Chief scientist's final data: Observed, Eotvos, Free Air Anomaly value at 00 seconds of each minute.

1980 theoretical gravity formula:

$$Y_0 = 978.0327 \times (1 + .0053024 \times \sin(\Theta) \times \sin(\Theta) - .0000058 \times \sin(2 \times \Theta) \times \sin(2 \times \Theta))$$

FORMAT: vt.nddd

yy+ddd:hh:mm:ss.mmm N 10 20.1234 W 120 23.1234 1980 77.1
yr. day time lat. lon. theog FAA
979317.5 64.1 1.5 10.2 -1.7 9.7 -1.6 9.8
raw_grav eotvos drift dc_shift raw_vel smo_vel

Lamont database: Free Air Anomaly value at 00 seconds of each minute.
1930 International gravity formula.

Note:
A '-' sign after the year in the record signifies a flagged record due to turn.

As a result of the discussion among the MG&G group, Lamont Data Reduction will use Port's Gravity Referenced Value without Potsdam correction for gravity data sent to MG&G data base at Lamont.
Further discussion also revealed that *1980 theoretical gravity formula* has incorporated Potsdam correction in its formula.

DAY	TIME	COMMENTS
286	1530	started data processing
294	1600	end of cruise ; stopped data processing

PRE-CRUISE GRAVITY TIE-IN:

Port: Dutch Harbor, Alaska, U.S.A.
Date: July 6, 1994 (JD 187)
Operator: Bruce A. Francis
Reference Station:
ACIC 2178-1
Reference Value: 981552.07 mGals

Pier/Ship's position:
R/V Ewing was at the pier by the Delta Western Warehouse. Moved here on July 6th to take on fresh water.

Gravity meter: *L & R Model G, serial number 237.*
Temperature of meter: 49 ^{0}C.
Readings and Calculations:

TIME	LOCATION	L&R READING	G	Potsdam Corr?
2015Z	Pier	5046.64+- .05		
2032Z	Ref	5046.43+- .05	981552.07	NO!
2042Z	Pier	5046.62+- .05		

TIME	GRAVITY	G READING
2042Z	BGM-3	981564.3
2042Z	KSS-30	1396.08

Pier reading 2.8 m above waist deck. Waist deck is 5.5 m above gravity meter.
Difference between pier and gravity meter : 5.5 + 2.8 = 8.3 m.

Lacoste difference in LR units:
delta_LR = pier_LR - ref_LR
0.19 = 5046.62 - 5046.43

Difference in mgal: (1 LR unit = 1.06 mGals)
delta_mgal = delta_LR x constant
0.2 = 0.19 x 1.06

Pier gravity value in mgal: ref_val = G (+13.6 if Potsdam corrected)

pier_grv_val = ref_val + delta_mgal
981552.27 = 981552.07 + 0.2

<u>Height correction</u>:
Height correction in mGals:

note: free-air constant of +0.31 mGals per meter going towards the center of earth; -0.31 mGals per meter going away.

hgt_corr = hgt x constant
2.57 mGals = 8.3 x 0.31 mGals/m

Gravity at gravity meter level in mGals:

grv_at_meter_level = pier_grv_val + hgt_corr
981554.84 = 981552.27 + 2.57

<u>KSS-30:</u>

KSS-30 value was smooth and time adjusted by 75 secs.

KSS_grav_val = kss_unbiased_output + bias
981556.37 = 1396.08 + 980170.29

Mistie in mGals:

mistie = KSS_grv_val - grv_at_meter_level
11.53 = 981556.37- 981554.84

Drift in mGals since last tie:

prev_mistie: 15.6 mGals on date May 20,1994 (JD 140)

drift = mistie - prev_mistie
-4.07 = 11.53 - 15.6

==> ***DC Shift*** = prev_mistie - bias
= 15.6 - 980170.29 = -980154.69

Drift/Day = drift / (tot. # of day)
= -4.07 / (187-140) = -0.0866 mGals/day

<u>BGM-3:</u>

BGM_filt_grv = (scale factor x counts) + bias = 979537.0
using s.f. 5.0940744 and bias 8526800, filter width 360. (6 minutes)

Mistie in mGals:

mistie = BGM_grv_val - grv_at_meter_level
9.5 = 981564.3 - 981554.84

Drift in mGals since last tie:

prev_mistie: 9.83 mGals on date May 20, 1994 (JD 140)
drift = mistie - prev_mistie
-0.3 = 9.5 - 9.83

==> ***DC Shift*** = prev_mistie
= 9.83

Drift/Day = drift / (tot. # of day)
= -0.3 / (187 - 140) = -0.0064 mgals/day

<u>POST-CRUISE GRAVITY TIE-IN</u>:

Port: Balboa, Canal Zone, Panama
Date: 26-27 November, 1994 (JD 330-331)
Operator: Bruce A. Francis
Reference Station:

The site is on the sidewalk on the west of the Captain of the Port building, in front of main entrance. The station was made in the middle of the circular concrete section on the sidewalk.
Date: 01 Nov. 1971 Position: N 8º 57.60' W 79º 33.81'

Pier/Ship's position:

R/V Ewing was docked at Pier 16. The tie point is midship, port side.

Gravity meter: *L & R Model G, serial number 237.*
Temperature of meter: 49 ºC.
Readings and Calculations:

TIME	LOCATION	L&R READING	G	Potsdam Corr?
JD 330 1915Z	Pier	1919.835 +- .05		
JD 330 2047Z	Ref.	1920.810 +- .05	978224.17	YES!!
JD 330 2055Z	Pier	1919.845 +- .05		

Note: Large tide variation in this port, and at the time of the measurement above it was difficult to note "C" deck height. It is only good to establish pier value.

TIME	GRAVITY	G READING
JD 331 1415Z	BGM-3	978252.06
JD 331 1415Z	KSS-30	1920.99

At 1415Z "C" deck was 1.52 m BELOW pier.
"C" deck is 5.5 m above gravity meter.
Difference between pier and gravity lab: 5.5 + 1.52 = 7.02 m

Lacoste difference in LR units:

delta_LR = pier_LR - ref_LR
-1.03 = 1919.84 - 1920.81

Difference in mGals: (1 LR unit = 1.0690 mGals)

delta_mgal = delta_LR x constant
-1.1 = -1.03 x 1.0690

Pier gravity value in mGals: rev_val = G + 13.6 if IT IS Potsdam corrected.

pier_grv_val = ref_val + delta_mgal + 13.6
978236.67 = 978224.17 + (-1.1) + 13.6

Height correction:

Height correction in mGals:

note: free-air constant of +0.31 mGals per meter going towards the center of earth; -0.31 mGals per meter going away.
hgt_corr = hgt x constant
2.18 mGals = 7.02 x 0.31 mGals/m

Gravity at gravity meter level in mGals:

grv_at_meter_level = pier_grv_val + hgt_corr
978238.85 = 978236.67 + 2.18

KSS-30:

KSS_grav_val = kss_unbiased_output + bias
978249.3 = -1920.99 + 980170.29

Mistie in mGals:

mistie = KSS_grv_val - grv_at_meter_level
10.45 = 978249.3 - 978238.85

Drift in mGals since last tie:

prev_mistie: 11.31 mGals on date Oct. 23, 1994 (JD 296)

drift = mistie - prev_mistie
-0.86 = 10.45 - 11.31

==> ***DC Shift*** = prev_mistie - bias
= 11.31 - 980170.29
= -980158.98 mGals

Drift/Day = drift / (tot. # of day)
= -0.86 / (331-296) = -0.02457 mGals/day

BGM-3:

BGM_filt_grv = (scale factor x counts) + bias = 979537.0
using s.f. 5.0940744 and bias 8526800.
The count was filtered with a 60 filter width, run thru filter1d -FG480, and s_bgm

Mistie in mGals:

mistie = BGM_grv_val - grv_at_meter_level
13.21 = 978252.06- 978238.85

Drift in mGals since last tie:

prev_mistie: 12.02 mGals on date Oct. 23, 1994 (JD 296)
drift = mistie - prev_mistie
1.19 = 13.21 - 12.02

==> ***DC Shift*** = prev_mistie
= 12.02

Drift/Day = drift / (tot. # of day)
= 1.19/ (331-296) = 0.034 mgals/day

APPENDIX 5. Software for Plotting Hydrosweep Multi-Beam Bathymetry Data

The Hydrosweep data are in a format given below. They may be plotted using software described in this appendix.

MBIO Data Format ID: 5
Format name: MBF_HSATLRAW
Informal Description: Raw Hydrosweep
Attributes: Hydrosweep DS, 59 beam, bathymetry and back scatter, ASCII, Atlas Electronik.

So, first thing you have to do is to uncompress them. The command in UNIX is as follows:
% uncompress 9414hs.d* (for a global uncompress of all the HS data)

Note: A compressed file is approximately 1/3 the original size. So you might want to make sure that you have enough disk space first.

(Written by Dave Caress and Dale Chayes)

Dear Colleague:

A new release of the MB-System software is now available via anonymous ftp.

MB-System is a software package for UNIX computing environments consisting of programs which manipulate, process, list, or display multibeam bathymetry and side scan data. MB-System is being developed at the Lamont-Doherty Earth Observatory of Columbia University with support from the National Science Foundation, SeaBeam Instruments, and Antarctic Support Associates.

The new version, 4.1, replaces the previous release of version 3.4 in December, 1993. This release includes many improvements to the package. Among the most significant changes are:

- MB-System now handles side scan as well as per-beam bathymetry and the associated beam amplitudes (the current generation of multibeam sonars all produce bathymetry, average beam amplitudes, and high resolution side scan in a single data stream).

- MB-System now handles data formats with both across track and along track distances for each bathymetry beam and side scan pixel (vital for data from such sonars as the SeaBeam 2112 and the Elac Bottomchart).

- MB-System now handles shallow water data properly.

- MB-System now includes support for many new data formats, including:

  SeaBeam SIO swathbathy format
  SeaBeam 2000 SIO swathbathy bathymetry format
  SeaBeam 2000 SIO swathbathy sidescan format
  SeaBeam URI format in Vax byte order
  Hydrosweep URI format in Vax byte order
  HMR-1 processed data format
  Simrad EM12 processed data from the RRS Darwin
  Simrad EM1000 raw data

Elac Bottomchart UNB format
Reson Seabat 9001 UNB format

- The graphical tools (mbedit and mbvelocitytool) are now coded using the Motif widget set, giving the code greater portability. Xview based versions are still available for users hopelessly stuck on Sun workstations running under the old operating system.

- The macros (mbm_plot and mbm_grdplot) work better and generate more pleasing first cut plots.

- The gridding program (mbgrid) now allows both weighted mean and median filter gridding. The optional interpolation in regions with no data is now performed using the same minimum curvature algorithm developed by Walter Smith and Paul Wessel for the GMT program surface.

- The swath contouring program (mbcontour) now has two contouring algorithms. The first is the original "ping-to-ping" contouring approach which is fast but works poorly when nearby pings overlap. The new algorithm constructs a triangular network out of the bathymetry points and contours that with no assumptions about order in the data; this method is slower but produces better maps in many cases.

- Improved memory handling has greatly increased the reliability of programs such as mbswath and mbgrid.

- The program mbswath can generate swath color fill plots with shading derived from beam amplitude values.

- MB-System proper now consists entirely of code written in C (the real-time pen plotting code still depends on some FORTRAN routines).

- Many, many less prominent refinements and bug fixes.

To obtain the compressed tarfile of the directory structure containing the source code, do the following:

```
% ftp lamont.ldgo.columbia.edu
Name:  anonymous
Password:  your_email_address
        ftp>  cd pub/swath_data
        ftp>  binary
        ftp>  get README
        ftp>  get MB-System.4.1.tar.Z
        ftp>  get annual.Z
        ftp>  quit
```

To uncompress:

```
% uncompress *.Z
```

To extract the directory structure, move the MB-System tar file to a disk with at least 50 MBytes of free space and do the following:

```
% tar xvf MB-System.4.1.tar
```

Information and installation instructions are found in the file mbsystem/README.

There are some additional files available by anonymous ftp that may be of interest:

mbedit.xview.4.1.tar.Z
mbvelocitytool.xview.4.1.tar.Z
MB-SystemExamples4.0.tar.Z

The first two contain source code and fully linked executables for Xview (Sun SPARC) versions of two interactive graphical tools, mbedit and mbvelocitytool. The third contains some sample data files and example shellscripts demonstrating the use of some of the MB-System programs.

In the next few months, we expect our development effort will focus on the following issues:

- Adding a few additional data formats already requested

(SIO swathbathy Hydrosweep, raw HMR-1, raw Simrad EM12).

- Expanding the MB-System examples into a full, proper tutorial.

- Building a mouse driven GUI environment for most-used MB-System utilities.

- Developing or adapting sidescan mosaicing capability.

- Developing a navigation/heading/pitch/heave/roll data editor.

When corresponding, please email to both of us, as one of us is generally out of town or otherwise unavailable at any given time. We will do our best to be responsive to bug reports and suggestions for improvements.

Cheers,

Dave Caress and Dale Chayes

David W. Caress
SeaBeam Instruments
141 Washington Street
East Walpole, MA 02037
(also at Lamont-Doherty Earth Observatory)
caress@seabeam.com or caress@ldeo.columbia.edu
voice: 1-800-SEABEAM or (508) 660-6000
fax:(508) 660-6061

Dale N. Chayes
Lamont-Doherty Earth Observatory of Columbia University
Route 9W, Palisades, N.Y. 10964
dale@ldeo.columbia.edu
voice: (914) 365-8434
fax:(914) 359-6940

FIGURE CAPTIONS

Fig. 7. Near-trace (ch. 150) constant offset section for Lines LARSE01R and LARSE02. As described in text processing included band pass filtering, automatic gain control (AGC), and water column mute. Figures 7a and 7b show Line LARSE01R and Figures 7c and 7d show Line LARSE02.

Fig. 8. Near-trace (ch. 150) constant offset section for Lines LARSE03 and LARSE06. As described in text processing included band pass filtering, automatic gain control (AGC), and water column mute. Figures 8a and 8b show Line LARSE03 and Figures 8c and 8d show Line LARSE06.

Fig. 9. Near-trace (ch. 150) constant offset section for Lines TR1A and B, TR2, and TR3. As described in text processing included band pass filtering, automatic gain control (AGC), and water column mute. Figure 9a show Lines TR1A and TR2. Figure 9b shows Lines TR1B and TR3.

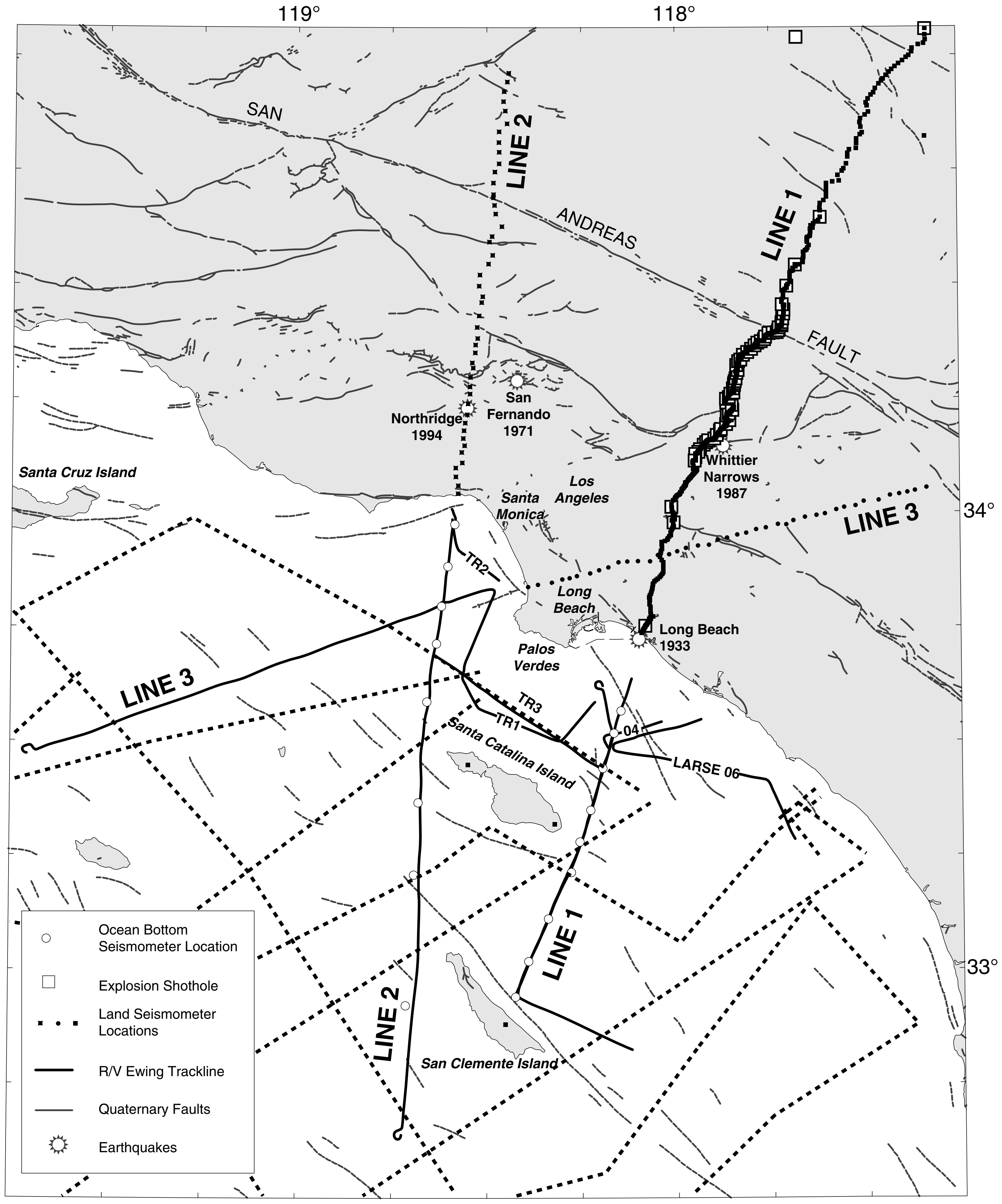


Fig. 1a. Map presenting an overview of offshore-onshore part of the LARSE experiment, showing locations of LARSE lines 1 to 6, and transit lines TR1 to TR3. Ocean Bottom Seismometer locations along lines 1 and 2 are shown as unfilled circles. Detailed view of land phase of LARSE along line 1 is also shown.

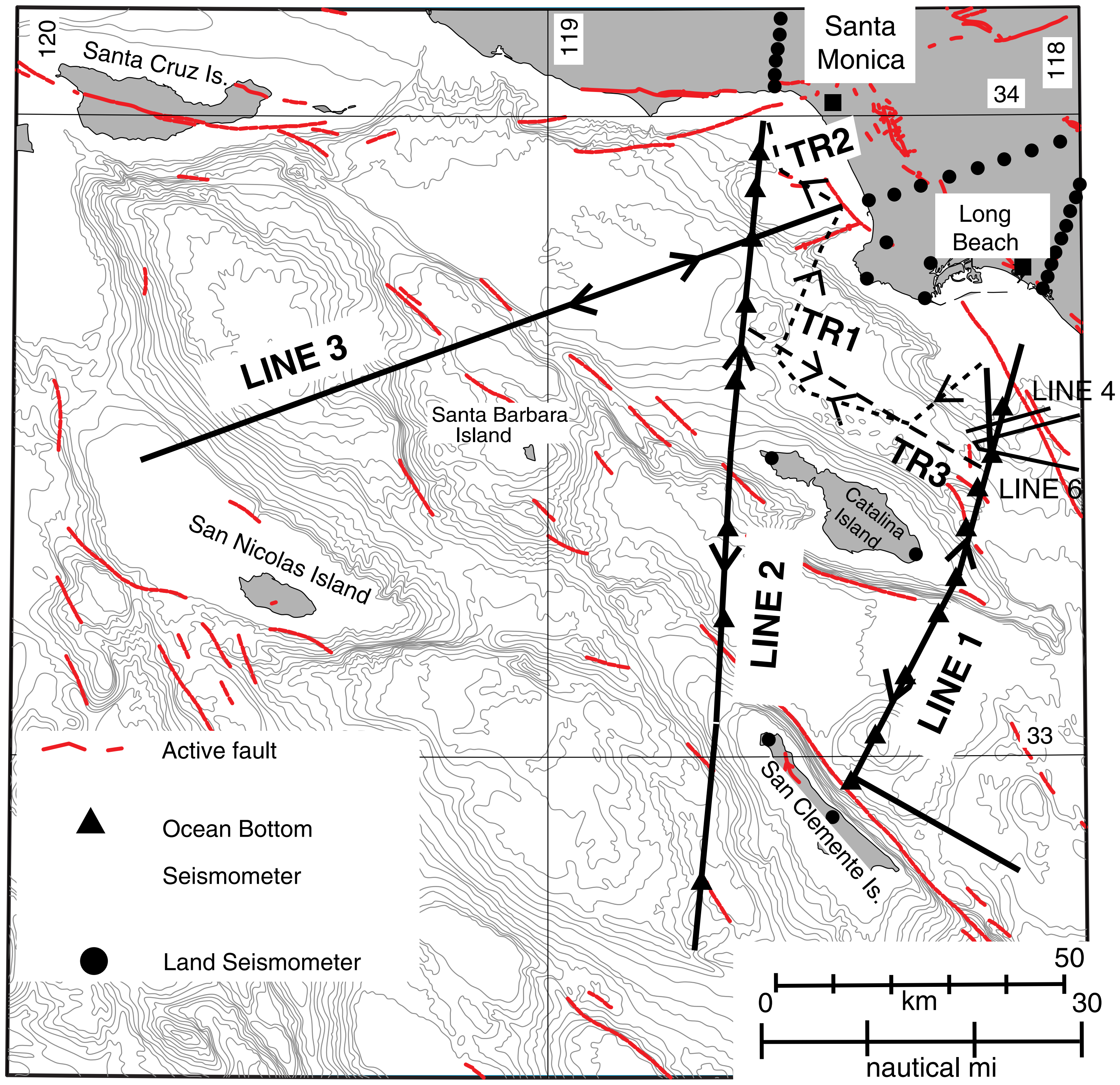


Fig. 1b. Detail map showing Ewing LARSE MCS reflection lines in Inner California Borderland. Unlabeled bathymetric contours provide indication of seafloor topography. Arrows along lines indicate direction ship traveled

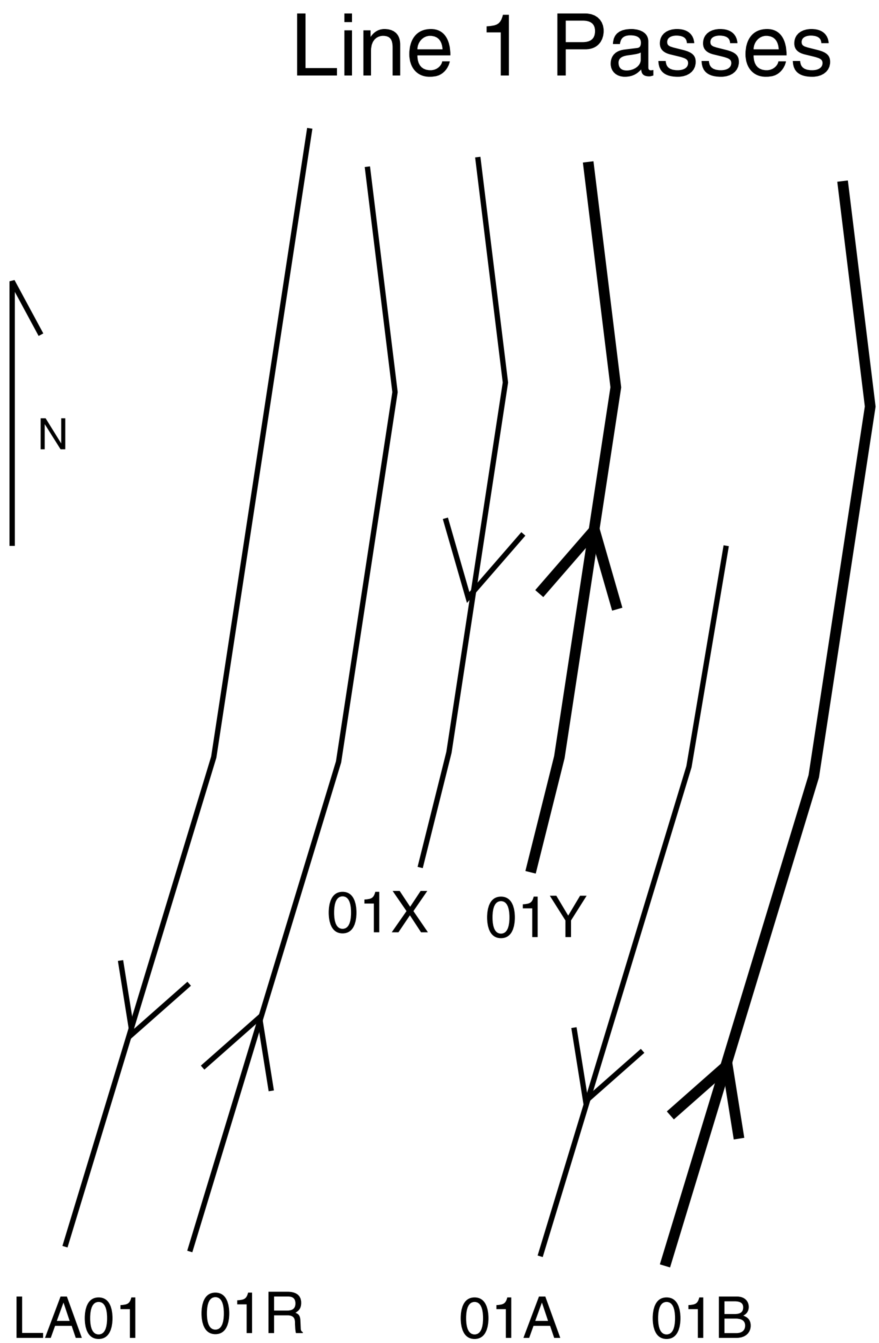


Fig. 2a. Schematic trackline plot for LARSE Line 1, showing the individual passes made over the line. Note that passes have been offset from each other for clarity. Arrow shows direction of **Ewing** track. Except for the first pass, LA01, the northern ends of all of the passes were kinked to the northwest to avoid the coastal shipping lanes. Heavy lines indicate ship tracks acquired during late night hours (2200 to 0600 L).

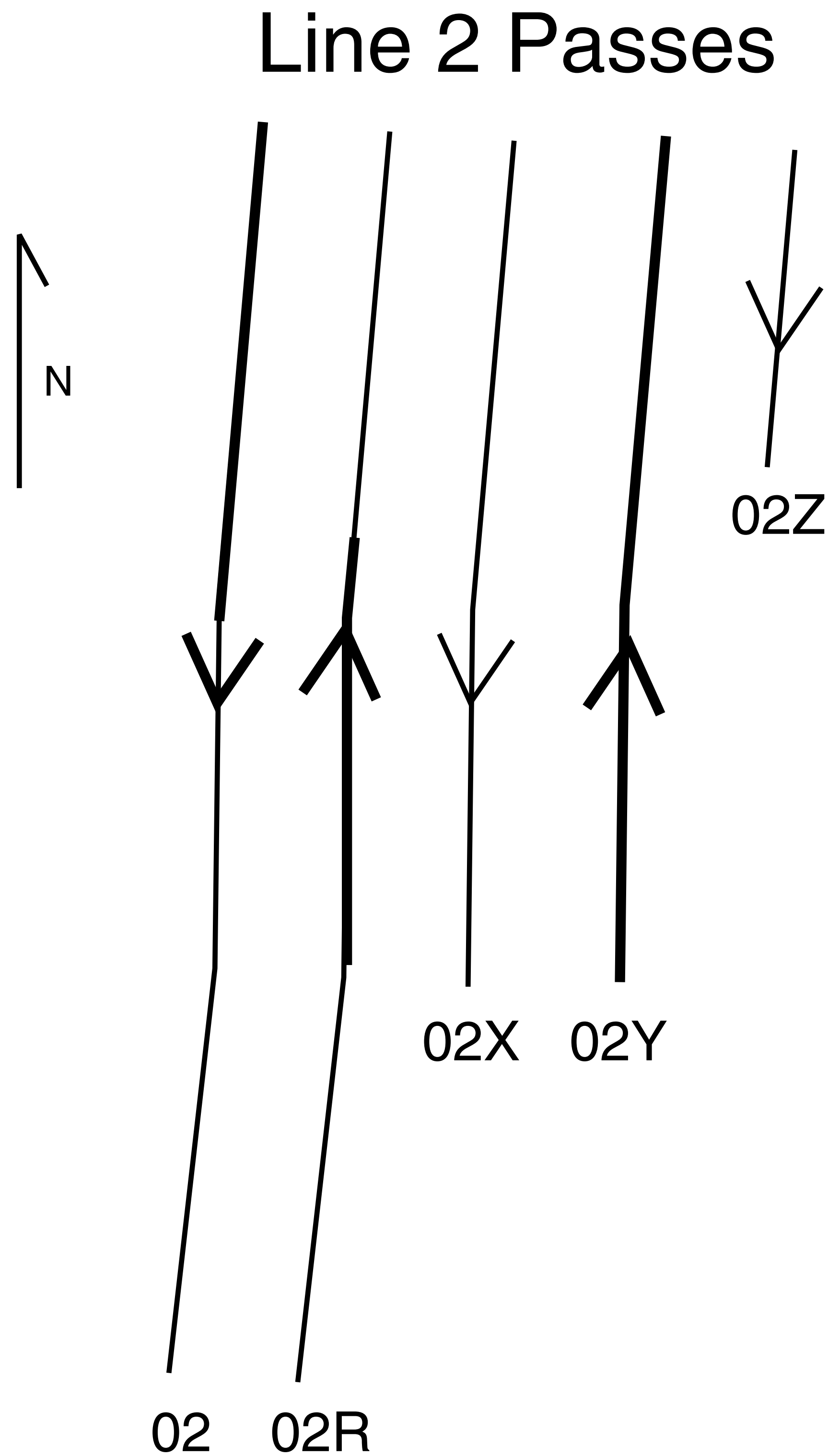


Fig. 2b. Schematic trackline plot for LARSE Line 2, showing the individual passes made over the line. Note that passes have been offset from each other for clarity. Arrows indicate direction of **Ewing** track. Heavy lines indicate tracklines acquired at late night hours (2200 to 0600 L).

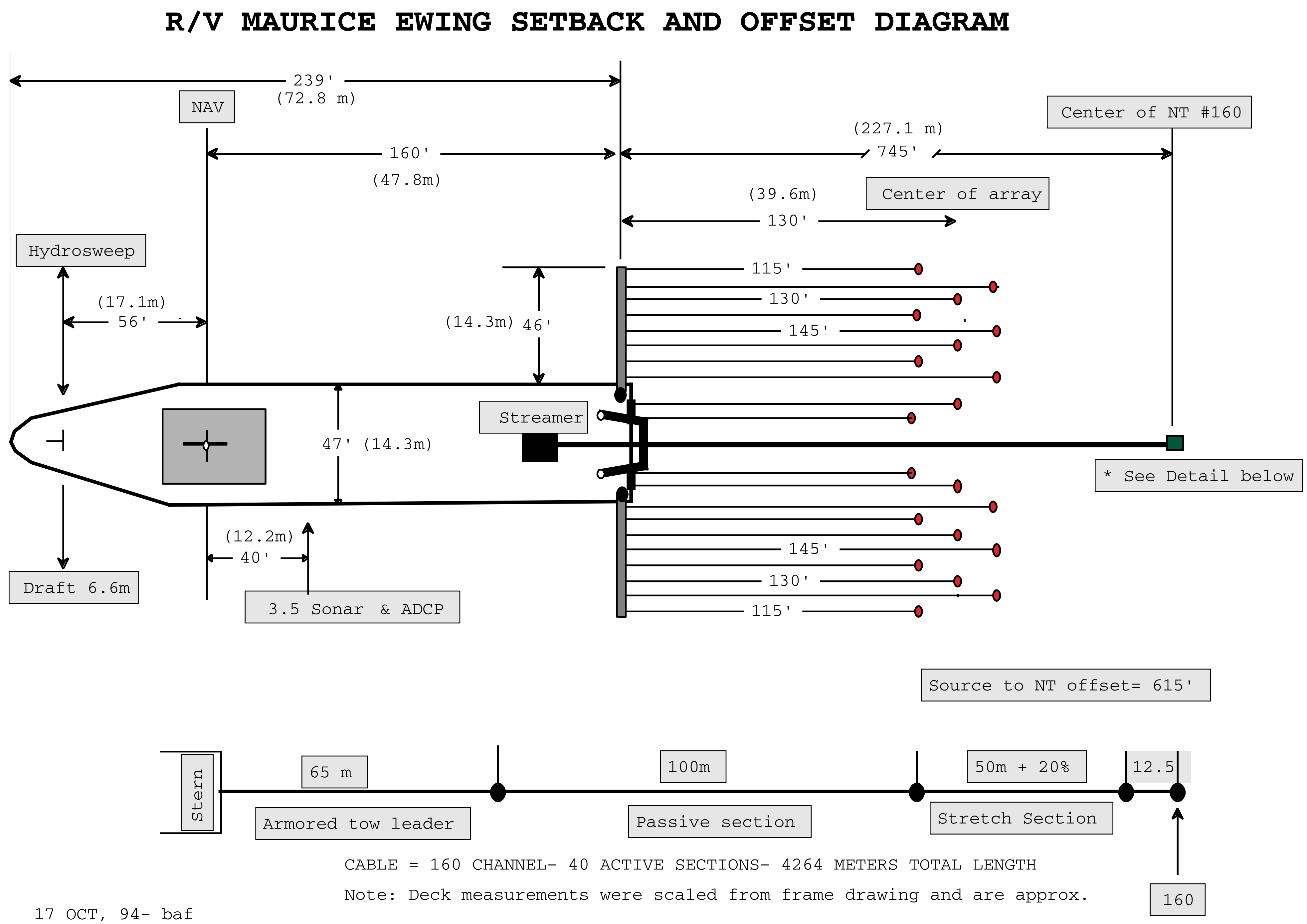
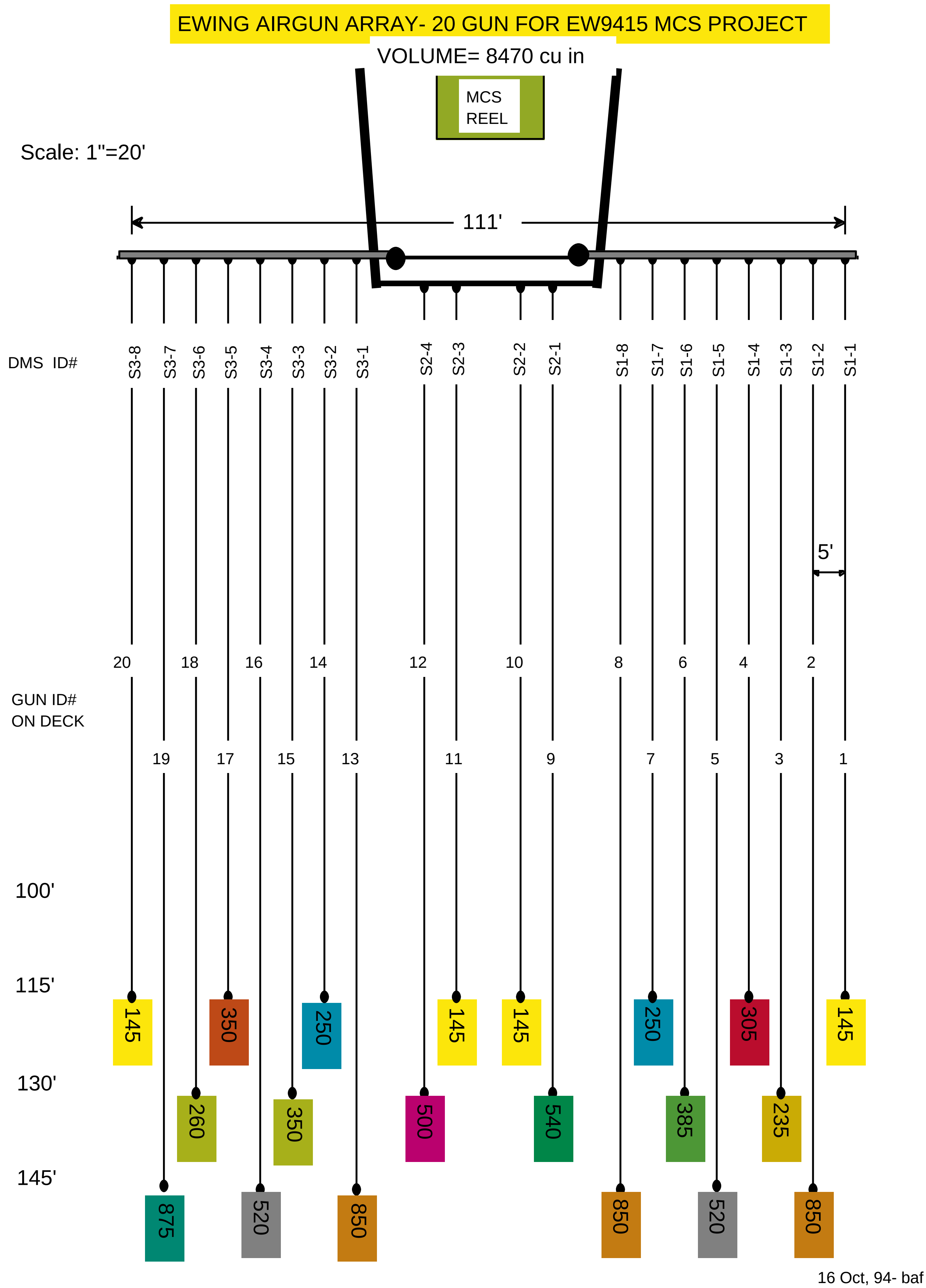


Fig. 3. Schematic diagram of **R/V Maurice Ewing** showing air gun and streamer deployment geometry.


EWING AIRGUN ARRAY- 20 GUN FOR EW9415 MCS PROJECT
VOLUME= 8470 cu in
MCS
REEL
Scale: 1"=20'
111'
DMS ID#
S3-8
S3-7
S3-6
S3-5
S3-4
S3-3
S3-2
S3-1
S2-4
S2-3
S2-2
S2-1
S1-8
S1-7
S1-6
S1-5
S1-4
S1-3
S1-2
S1-1
5'
GUN ID#
ON DECK
20
18
16
14
12
10
8
6
4
2
19
17
15
13
11
9
7
5
3
1
100'
115'
130'
145'
145
350
250
145
145
250
305
145
260
350
500
540
385
235
875
520
850
850
520
850
16 Oct, 94- baf

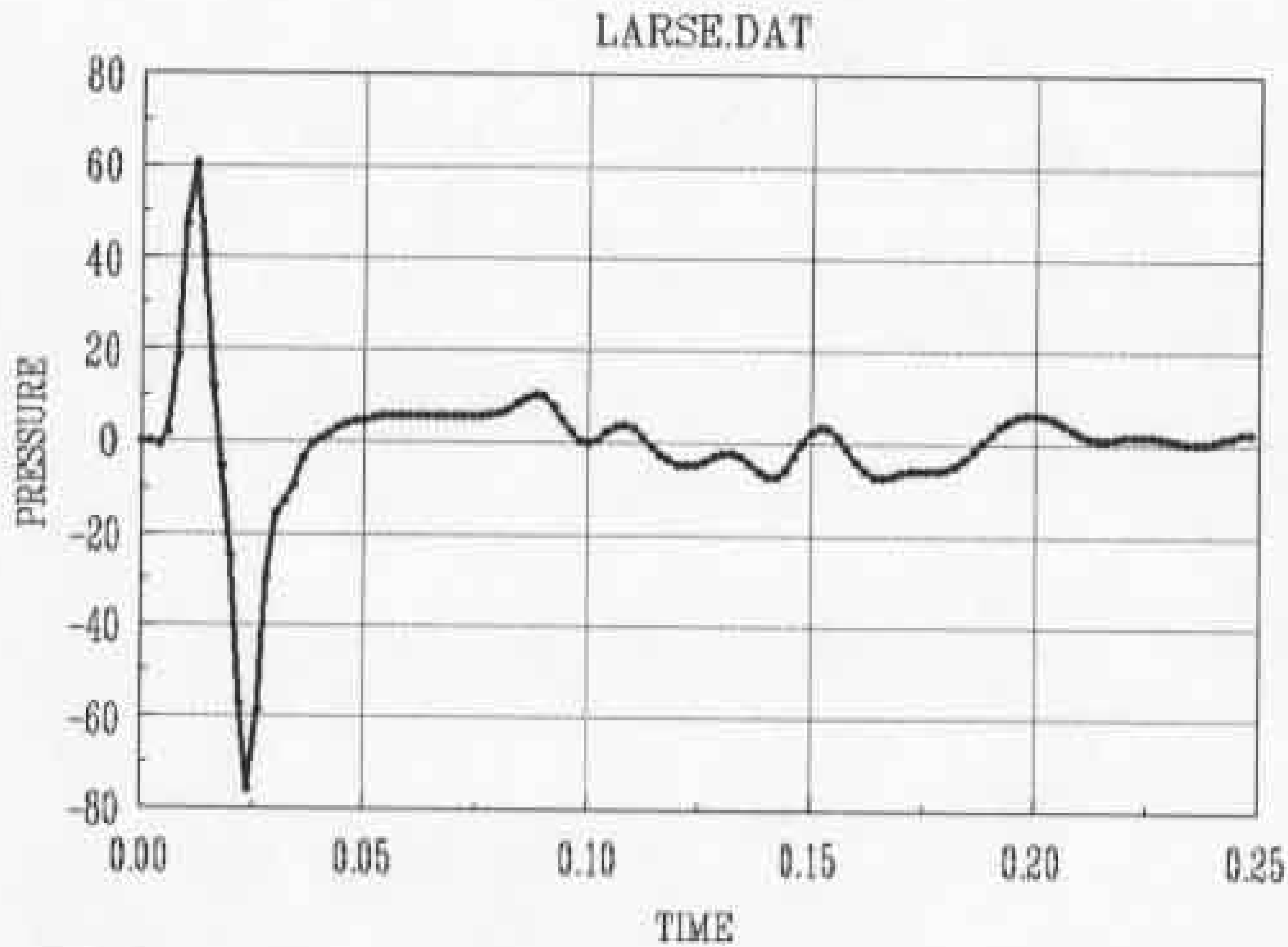


Fig. 5. Calculated source air gun wavelet for the 20-element , 8470 cu. in. array used by the **R/V Maurice Ewing.** Pressure is shown in bar-meters and time is shown in seconds.

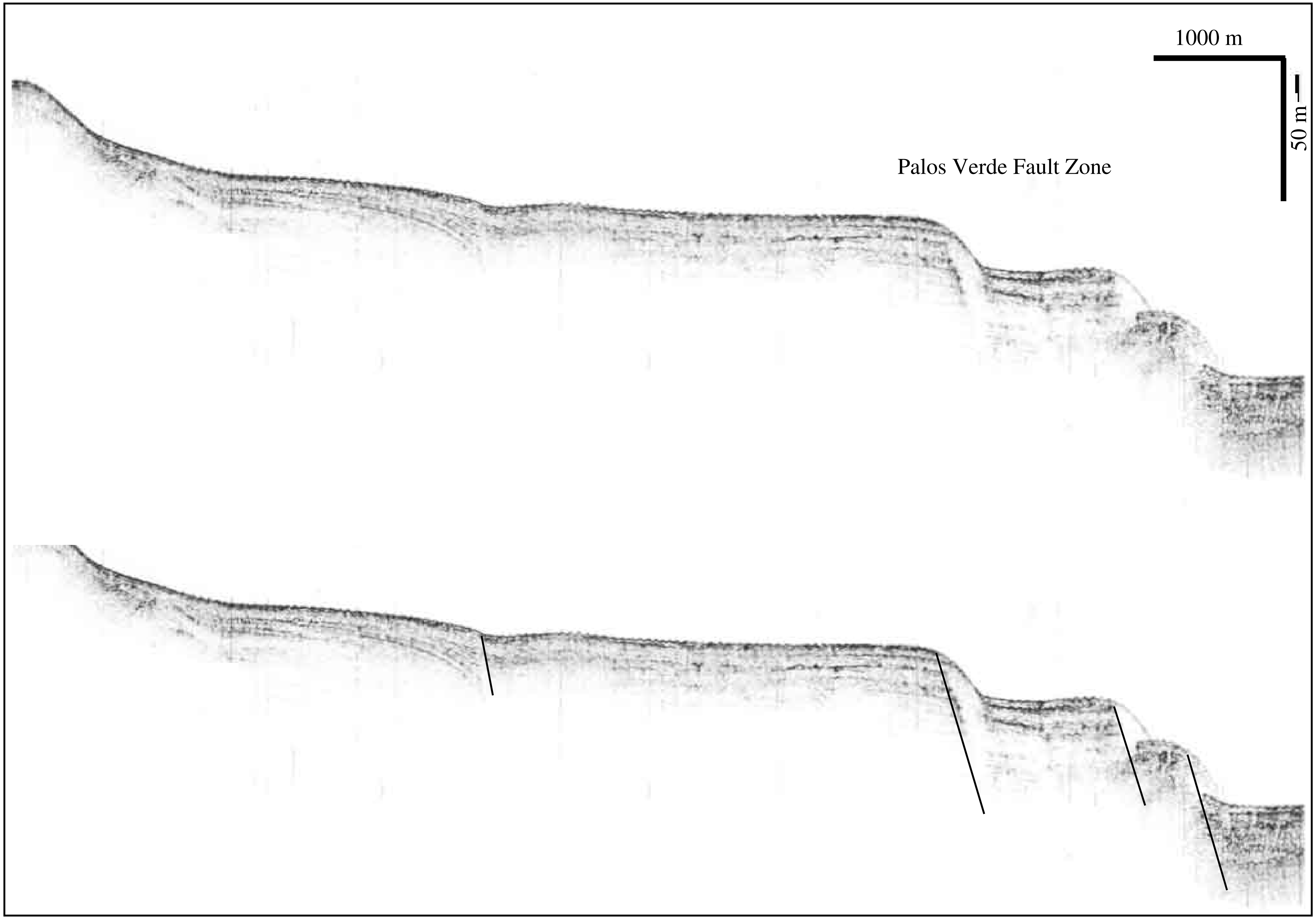
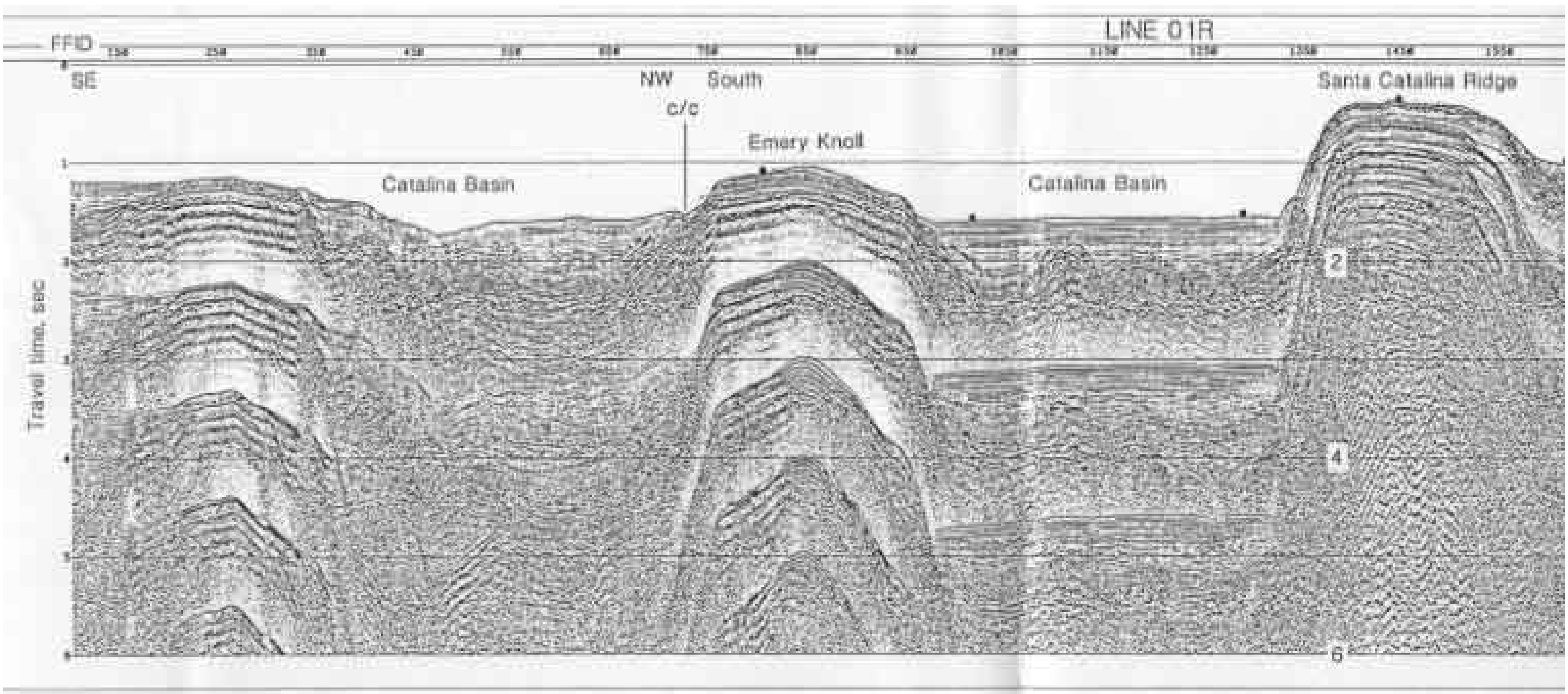
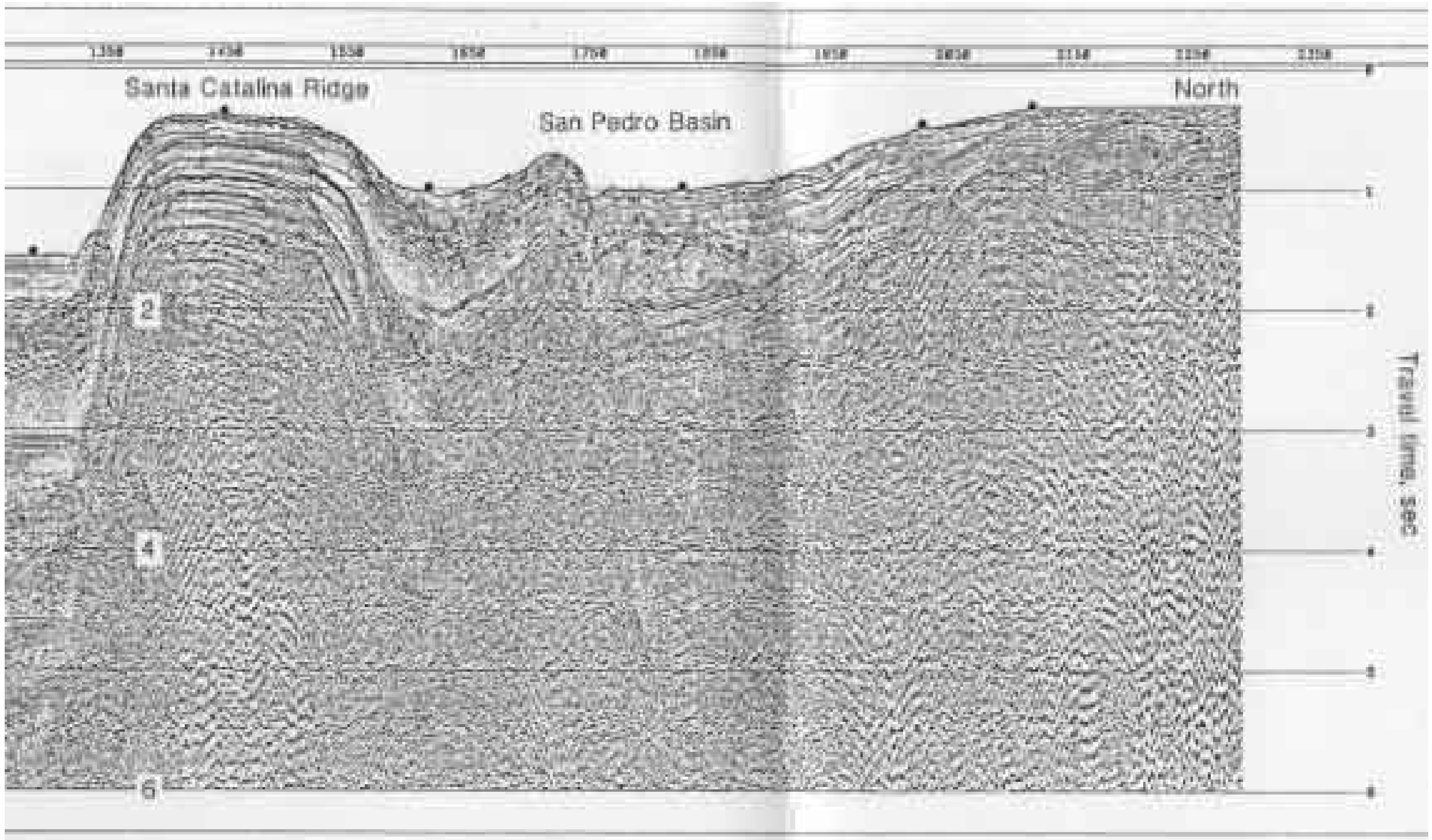


Figure 6. Example of 3.5 kHz bathymetry profiler record from Line LARSE04 across Palos Verde fault zone.



LINE 01R
FFID
SE
NW
South
c/c
Santa Catalina Ridge
Emery Knoll
Catalina Basin
Catalina Basin
Travel time, sec
2
4
6



Santa Catalina Ridge
San Pedro Basin
North
2
4
6
Travel time, sec

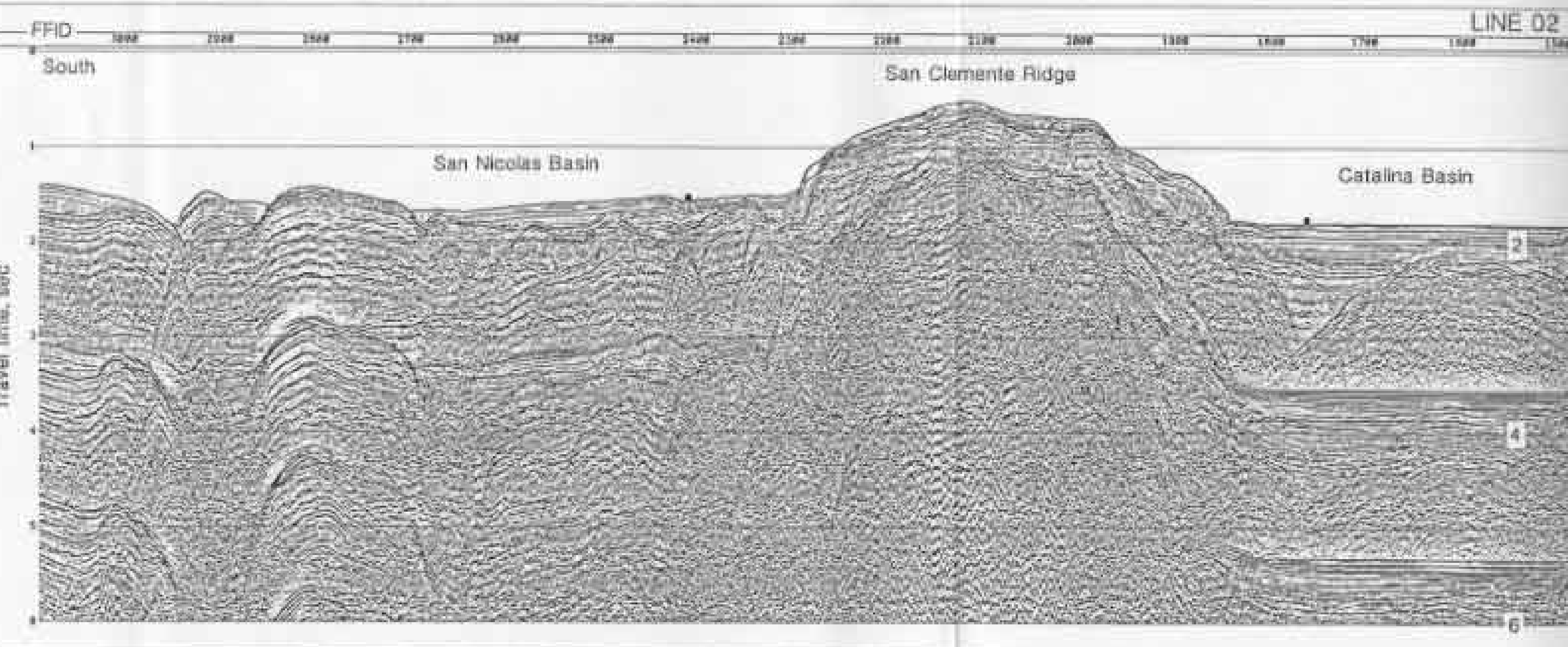
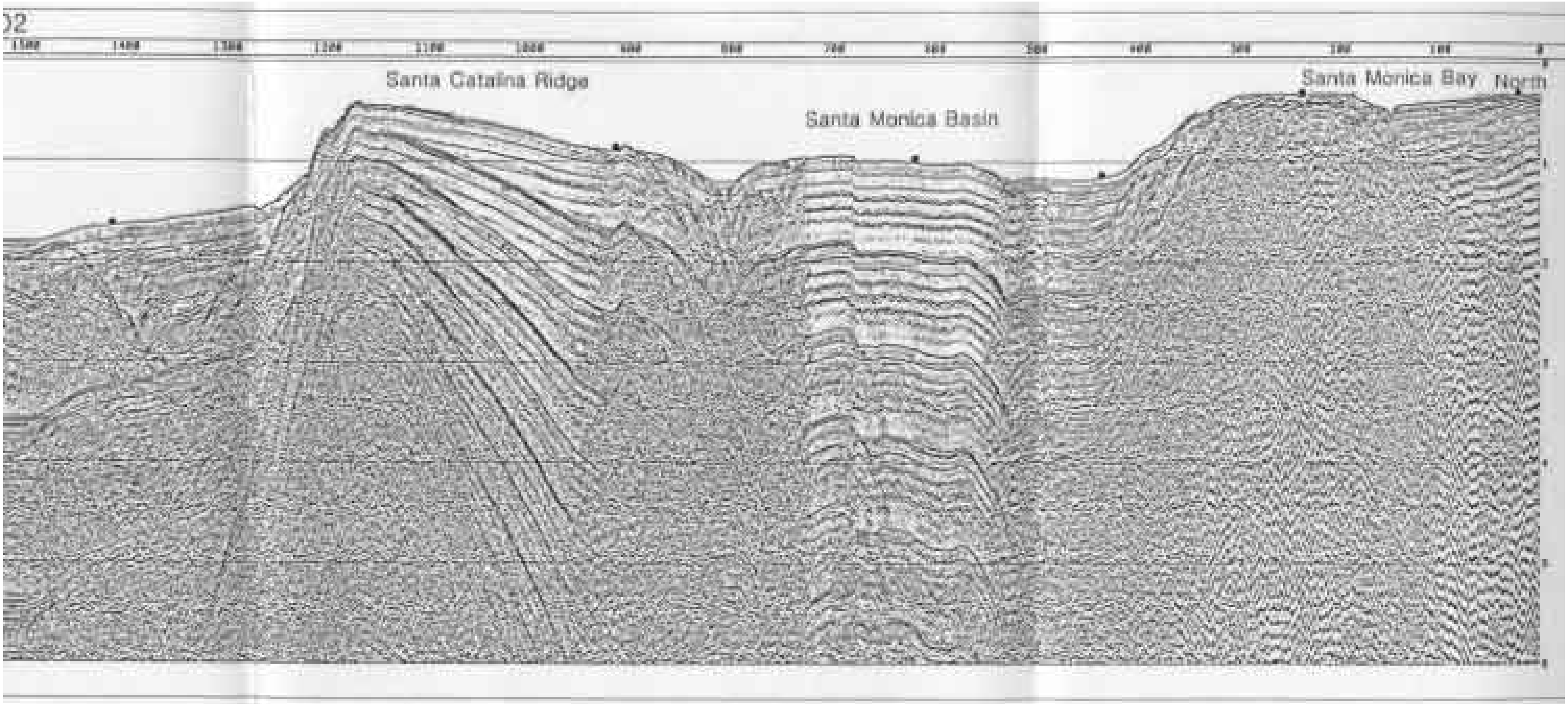
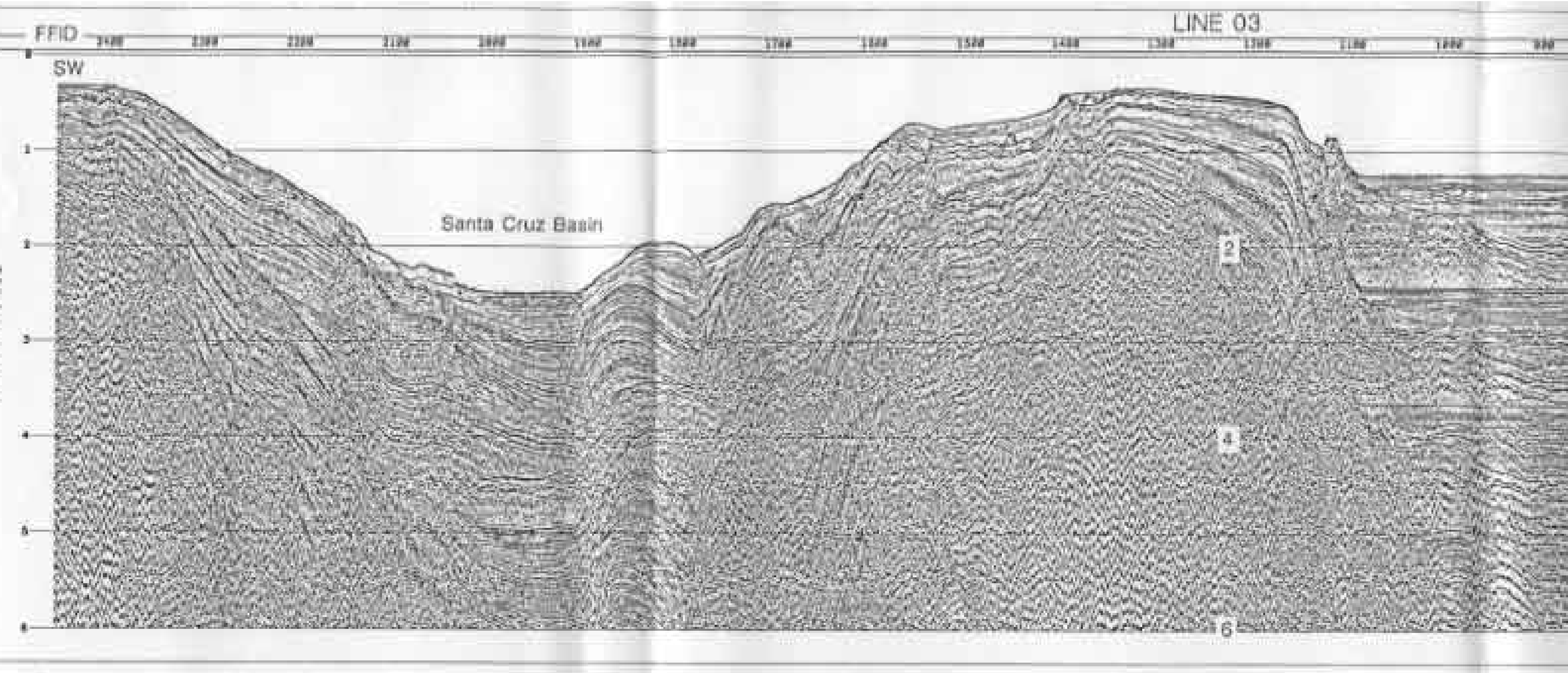
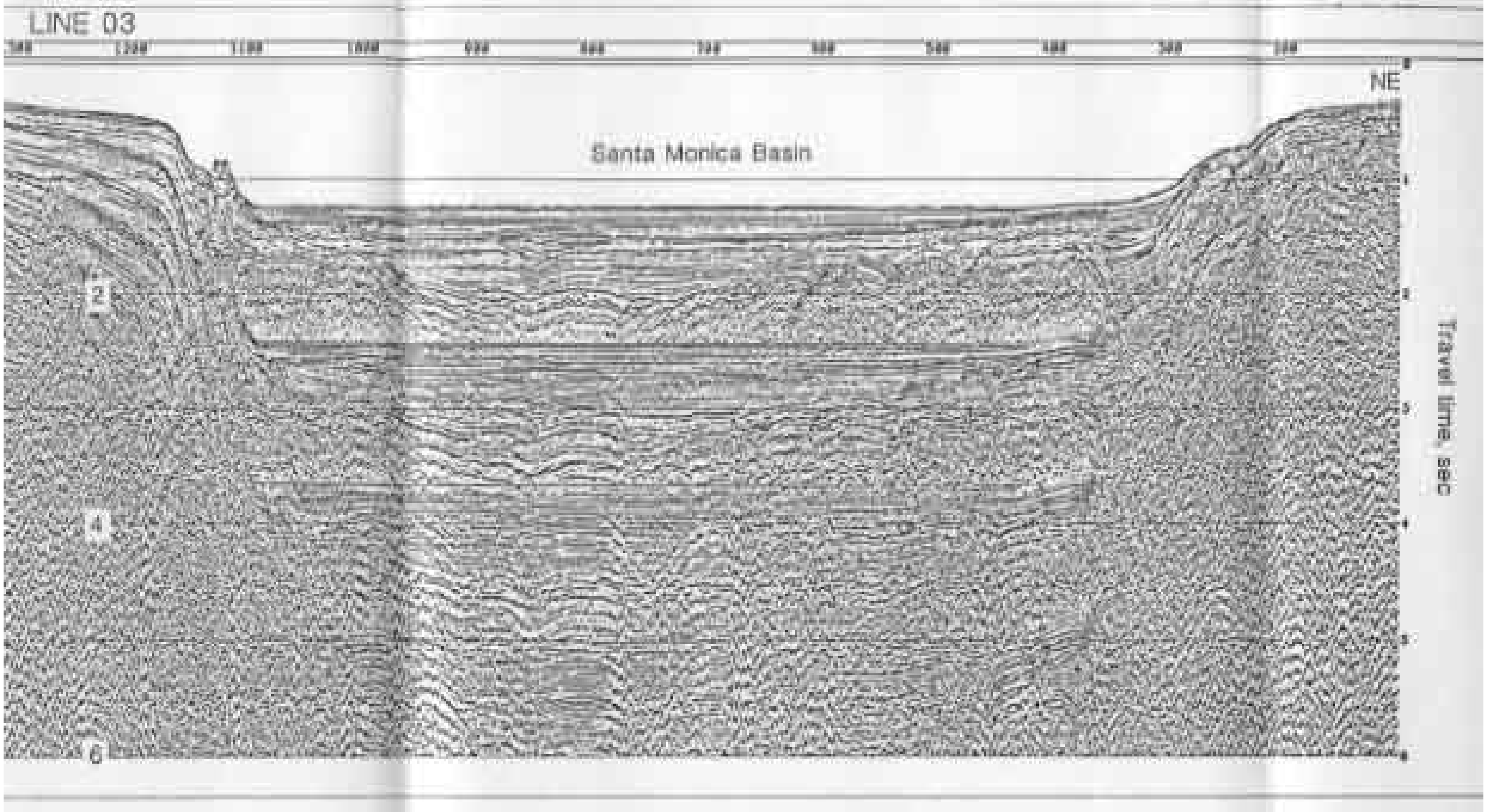


Fig. 7. Near-trace (ch. 150) constant offset section for Lines LARSE01R and LARSE02. As described in text processing included band pass filtering, automatic gain control (AGC), and water column mute.



02
Santa Catalina Ridge
Santa Monica Basin
Santa Monica Bay
North


LINE 03
FFID
SW
Santa Cruz Basin
2
4
6


LINE 03
Santa Monica Basin
NE
2
4
6
Travel time, sec

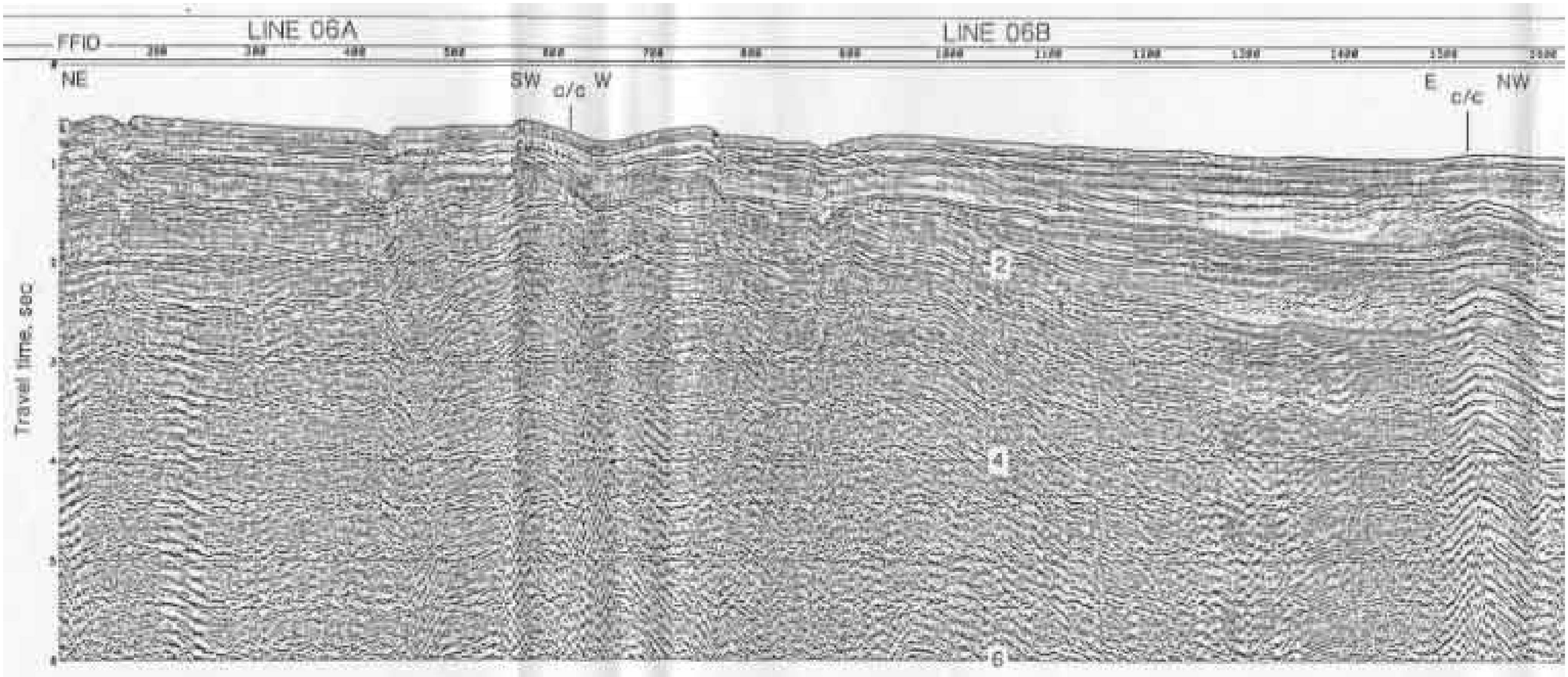
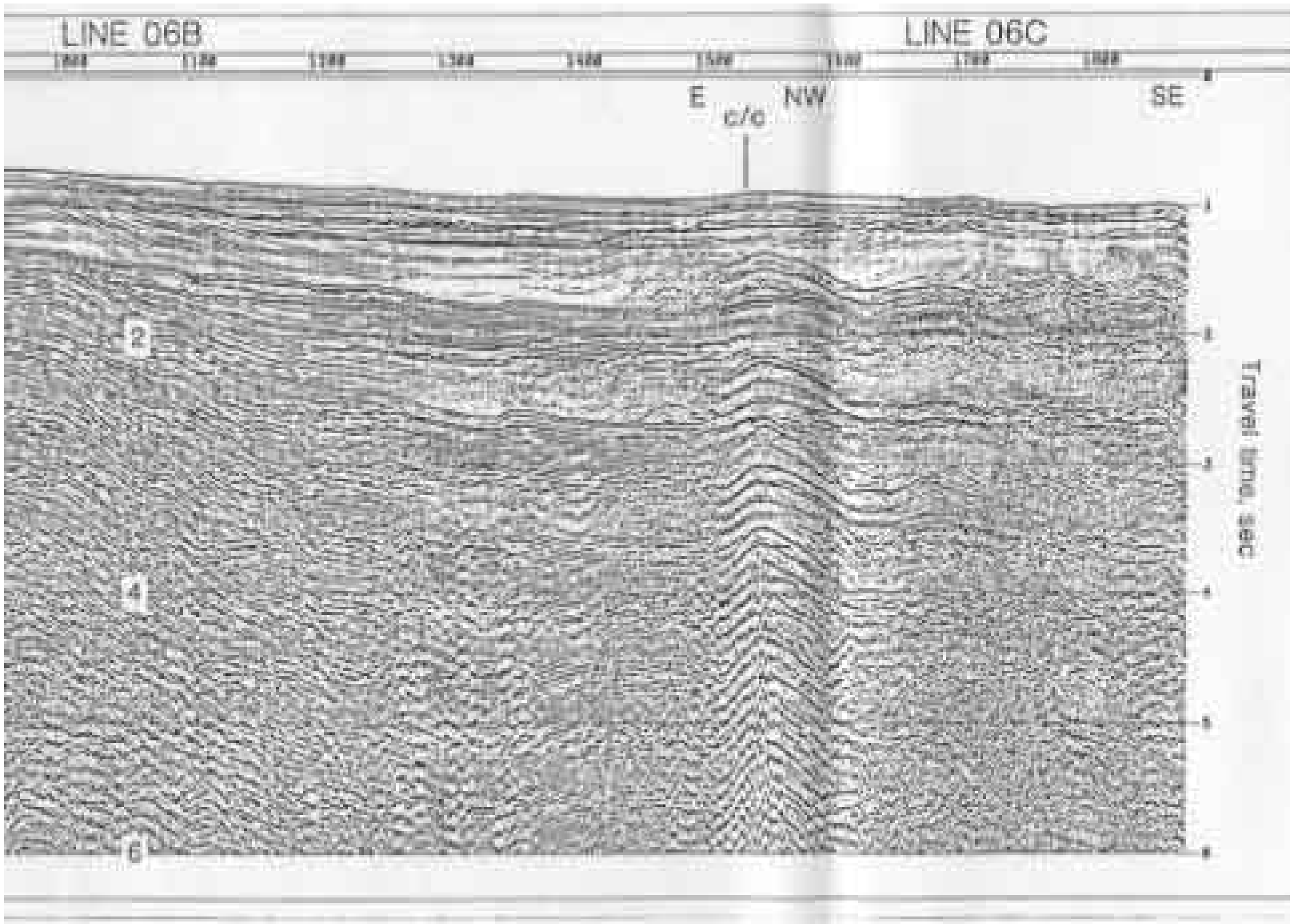
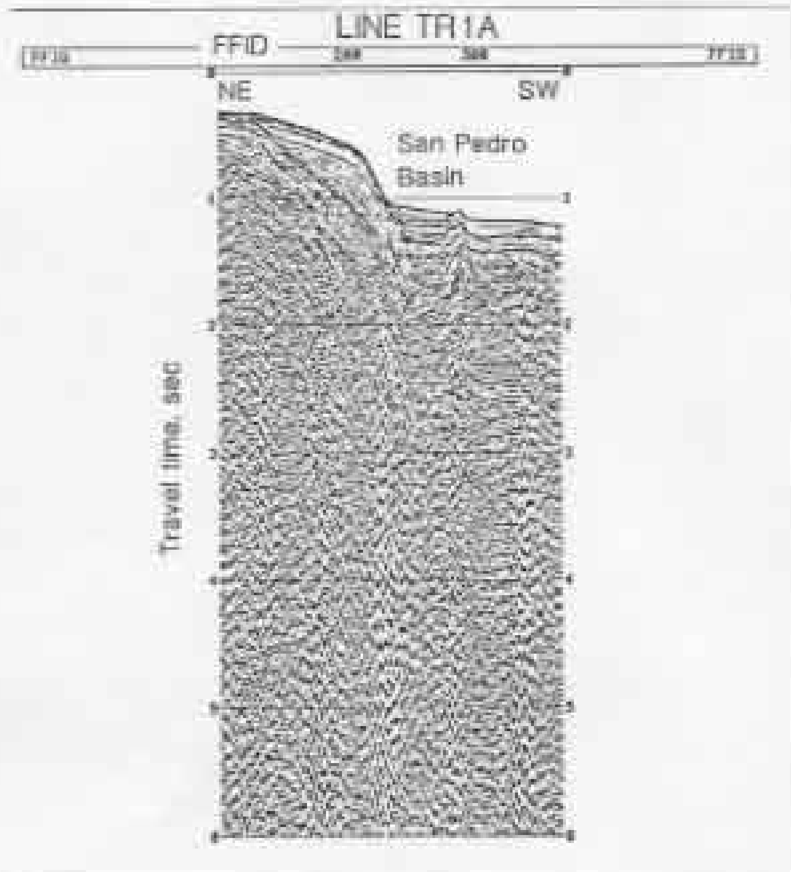


Fig. 8. Near-trace (ch. 150) constant offset section for Lines LARSE03 and LARSE06. As described in text processing included band pass filtering, automatic gain control (AGC), and water column mute.


LINE 06B
LINE 06C
E
c/c
NW
SE
2
4
6
Travel time, sec



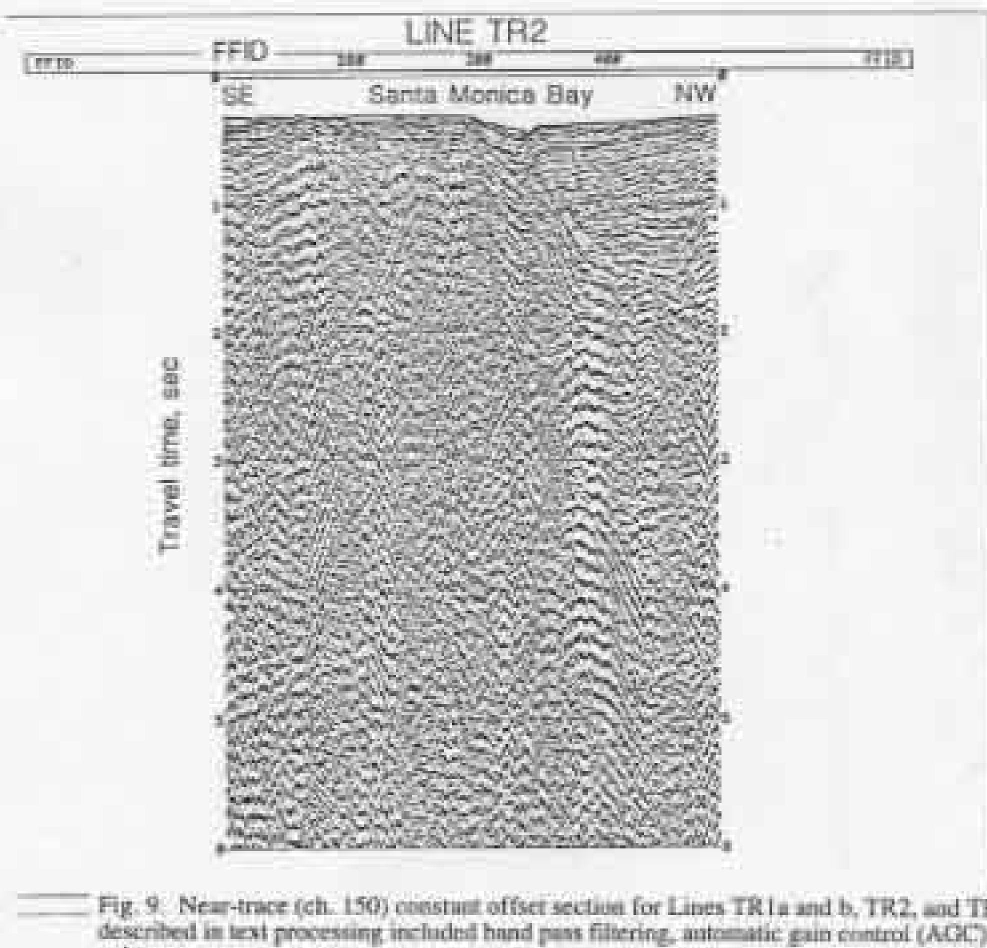
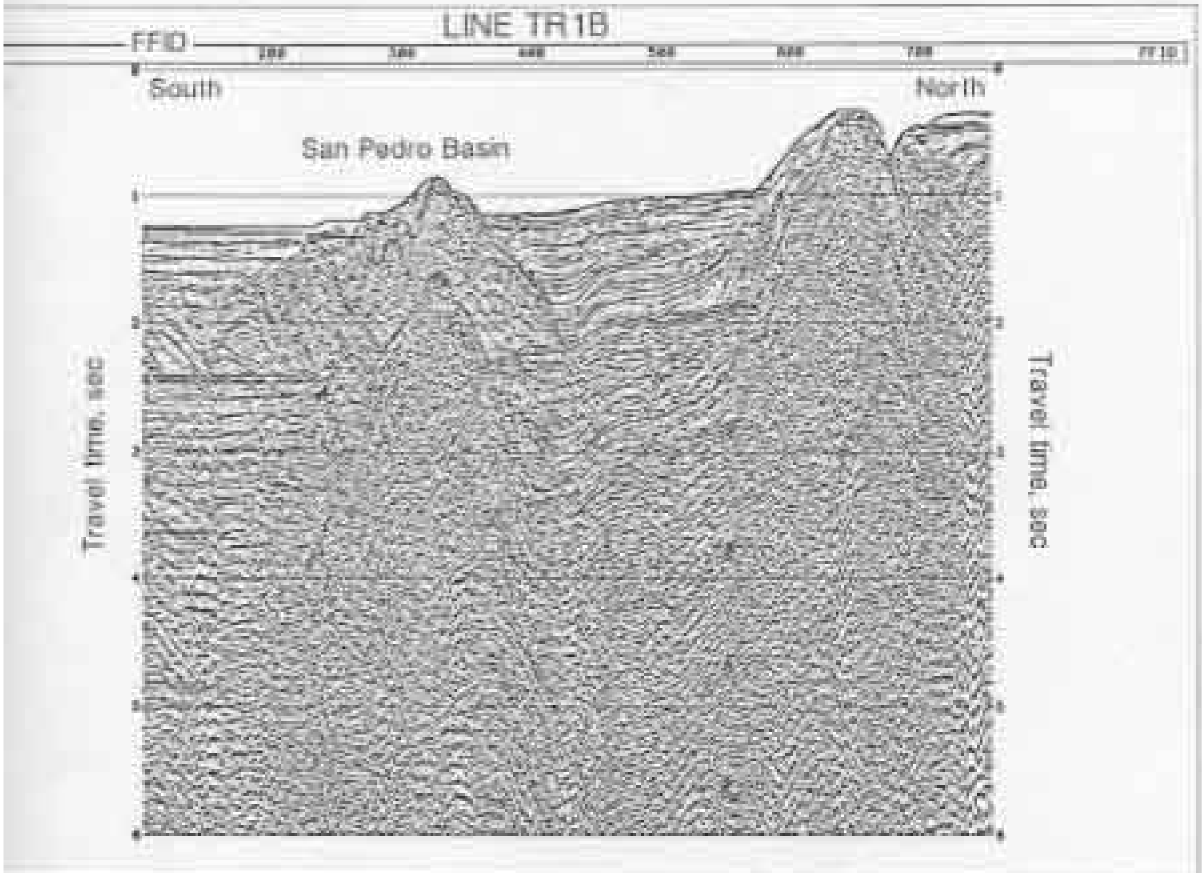
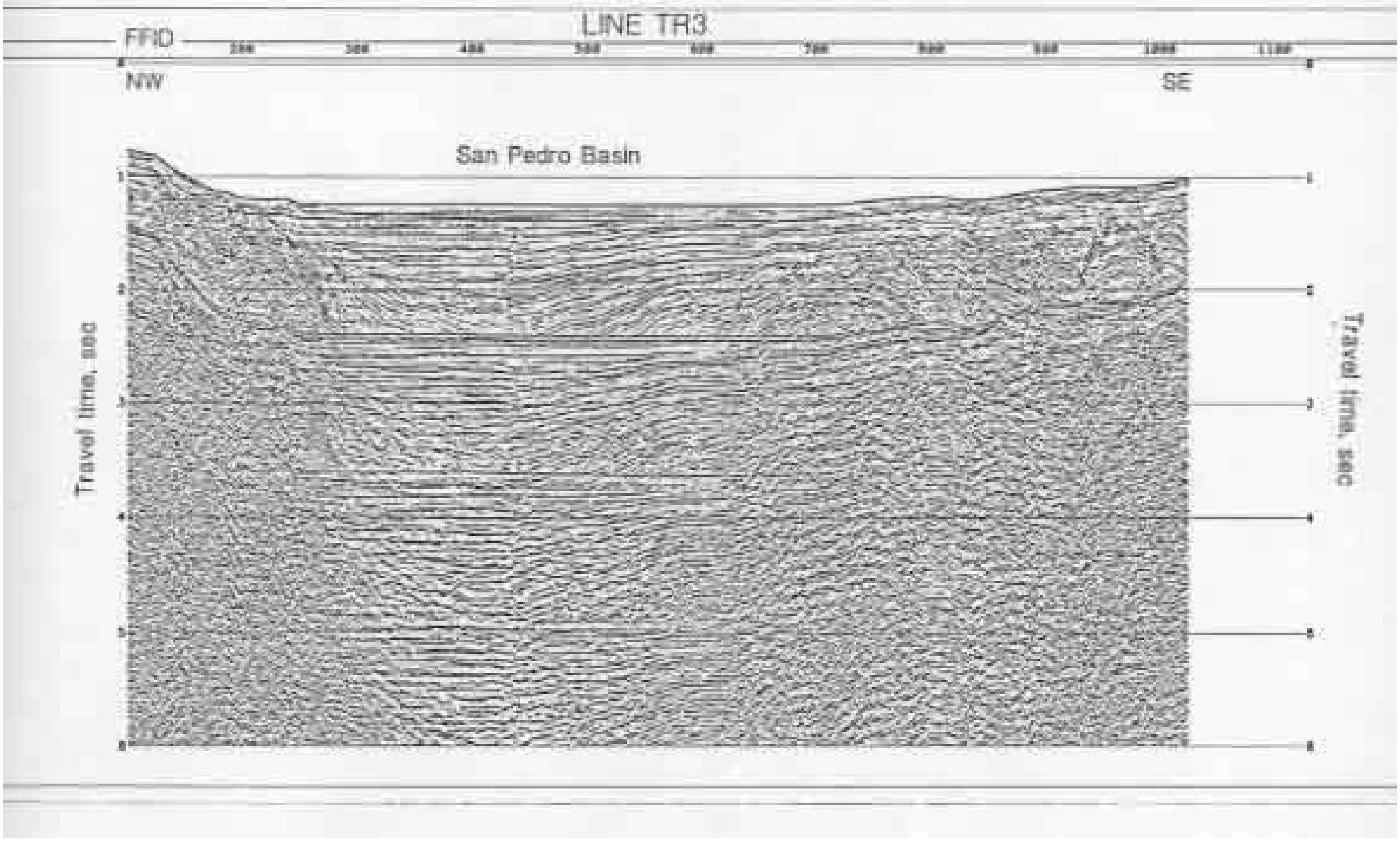


Fig. 9. Near-trace (ch. 150) constant offset section for Lines TR1a and b, TR2, and TR3. As described in text processing included band pass filtering, automatic gain control (AGC), and water column mute.


LINE TR1B
FFID
South
North
San Pedro Basin
Travel time, sec
Travel time, sec


LINE TR3
FFID
NW
SE
San Pedro Basin
Travel time, sec
Travel time, sec