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Cruise Report

A Two-Ship Multichannel Seismic Experiment on the East Pacific Rise South of the Garrett Fracture Zone

R/V *Maurice Ewing*
R/V *Thomas Washington*

March - May 1991

Co-Chief Scientists

R/V *Ewing*:	Robert Detrick John Mutter
R/V *Washington*	John Orcutt Alistair Harding

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Cruise Report EW 91-02

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1.0 Background and Objectives

This report summarizes the operations during R/V *Maurice Ewing* cruise EW 91-02, a two-ship multichannel seismic (MCS) investigation of the East Pacific Rise (EPR) south of the Garrett fracture zone carried out with the R/V *Thomas Washington*. The principle goal of this study was to investigate crustal accretion processes, and particularly the nature of crustal magma bodies, along a portion of the global mid-ocean ridge system that is spreading near the fast end of the accretionary spectrum. Results from earlier seismic studies, including a 1985 multichannel seismic investigation, along the intermediate-spreading northern EPR (9°-13°N) have provided strong support for the existence of crustal magma chambers at fast spreading ridges. However, the dimensions of the magma bodies inferred from these experiments are much smaller than those assumed in many crustal accretion models. The predominantly molten part of the magma chamber documented along the northern EPR is <1-2 km wide and probably less than a few hundred meters thick, although reflections from the roof of this body can be traced as a relatively continuous feature for tens of kilometers along the rise axis.

Few constraints are available on the existence and dimensions of crustal magma chambers on a more regional scale along the EPR, or globally along the mid-ocean ridge system. By working on a portion of the mid-ocean ridge where the thermal regime and magma supply rates are expected to be the most conducive for the existence of large, steady-state magma chambers, we hope to use the data collected on EW 91-02 to place an upper bound on the size of crustal magma bodies along the mid-ocean ridge system and their potential role in the crustal accretion process. Other specific objectives of this study include: (1) by comparison with previous experiments determining if there is a spreading rate dependence to magma chamber size, (2) constraining better the relationship between the tectonic and geochemical segmentation of the rise axis and the along-strike continuity of the axial magma chamber, (3) determining how the first-order seismic structure of oceanic crust develops during the first 100,000 years after crustal formation, and (4) determining if sub-Moho structure indicative of large-scale mantle flow can be resolved near the EPR.

2.0 Tectonic Setting

The EPR south of the Garrett fracture zone and north of the Easter microplate is shown in plan view and in profile in Figures 1 and 2. Spreading rates along this portion of the EPR are 150-155 mm/yr, just slightly lower than the 159 mm/yr total opening rate of the EPR near 31°S, the world's fastest spreading ridge. The ridge axis in this region has been mapped by Sea Beam and SeaMARC II, and has been extensively dredged. The rise axis is uninterrupted by transform faults for a distance of 1150 km between the Garrett fracture zone and the northern edge of the Easter microplate. A large right-stepping OSC/propagating rift offsets the ridge at 20.7°S. South of this boundary the rise axis is offset by a series of small, right-lateral non-transform offsets; north of 20.7°S the rise axis mainly steps to the left across a number of small OSCs and Devals. The rise crest is deepest at 20.7°S, but shoals rapidly to the north and is shallowest (<2600 m) and broadest near 18°20'S. North of this area, the rise axis is remarkably uniform in depth all the way to the Garrett transform, deepening only in the immediate vicinity of the minor offsets at 16°25'S and 15°55'S, and within 50 km of the Garrett transform. Figure 2 also shows the magmatic segmentation of this part of the EPR defined geochemically by Sinton et al. [*J. Geophys. Res.*, **96**, 6133-6156, 1991]. There is generally a close correspondence between magmatic and tectonic segment boundaries, although some very subtle morphological features (e.g. the Deval at 14°30'S) mark surprisingly large compositional boundaries. For descriptive purposes in this report we will use the segment names A-G for the EPR between 23°S and 13°S as defined by Sinton et al. and shown in Fig. 2.

3.0 Experimental Methods

The Southern EPR (or SEPR) seismic experiment carried out on EW 91-02 was a combined two-ship MCS/OBS program involving the R/V *Maurice Ewing* and R/V *Thomas Washington.* Three types of seismic data were collected during the SEPR experiment; (1) CDP reflection data, (2) two-ship Expanding Spread Profiles (ESPs), and (3) OBS seismic refraction data. The source used for CDP reflection profiling was *Ewing's* 20-gun, 8385 cu. in. airgun array. CDP reflection data were obtained in one of three modes; firing the full 20-gun array every 20 s, firing alternative port and starboard halves of the array every 10 s, and during ESPs shooting the whole array every minute to collect a low-fold CDP line along each ESP profile. For a nominal ship's speed of 5 kts, these different shooting modes resulted in a shot spacing of 50 m, 25 m and 150 m, respectively. Seismic reflection data were received on a 4-km long, 160 channel digital streamer with a 25 m group separation. Data were recorded with a 4 ms sample interval using either 8.8 s or 18.75 s records on *Ewing's* DSS-240 recording system. This seismic acquisition system is considerably more powerful than the 48-channel, 2.4 km streamer and 1864 cu. in source employed in the 1985 northern EPR MCS study.

For the ESPs, the *Ewing's* 160 channel streamer recorded arrivals from shots of *Washington's* 6-gun, 2850 cu. in. airgun array. A one minute shot interval was used yielding a nominal shot-receiver spacing of 300 m. Ship-to-ship ranging for the ESPs will be based on differential GPS positions using identical Magnavox MX 4200 receivers placed on each ship. During the ESPs *Ewing* also recorded a low-fold CDP profile by shooting its full 20-gun array between successive *Washington* shots. Six Scripps OBS were deployed in three different areas during the course of the experiment and recorded both *Ewing* and *Washington* shots. In addition to the seismic data described above, Hydrosweep bathymetry, gravity and magnetic data were recorded throughout EW 91-02. Two different gravimeters were aboard, a BGM-3 system and a KSS-30 instrument, although the BGM-3 record was very noisy and probably is not useable.

4.0 Data Acquisition

Figure 3 shows the principle areas in which seismic data were obtained on EW 91-02. A series of CDP reflection profiles were shot north along the axis of the EPR from the large propagator/ OSC at 20.7°S to the Garrett transform at 13.4°S, a distance of over 800 km. Periodically, short (~20 km long) cross-axis profiles were also obtained across selected ridge segments. ESP/OBS data, and a large number of closely-spaced cross-axis CDP lines, were obtained in three detailed study areas at 17°20'S, 14°15'S and the 15°55'S OSC (see Figures 5-9). Appendix 1 includes a complete listing of the MCS/ESP line numbers, locations, acquisition and recording parameters and tape, shot and file numbers. Appendix 2 lists the location of sonobuoys launched during EW 91-02 and Appendix 3 includes *Ewing-to-Washington* bearing information for each ESP crossing.

The remainder of this section of the EW 91-02 Cruise Report is a day-by-day narrative of the operations aboard *Ewing* during the SEPR experiment. A discussion of our preliminary results and some general comments and recommendations begin on page 18.

<u>21 March 1991 (Thurs)</u> - At ~1500L (1900Z) the R/V *Maurice Ewing* sailed from Punta Arenas, Chile on leg EW 91-02, a 2-ship multichannel seismic experiment on the southern EPR. The scientific party sailing on EW 91-02 is listed in Table 1.

<u>22 March 1991 (Fri.)</u> - Streaming southwest out of Punta Arenas through the Straits of Magellan, we turned north into Smyth Canal, part of the "inside passage" along the Chilean coast. It took about 4 days to make our way 600 miles north to Ancud (near Pt. Montt) where we let the pilots off and picked up more streamer sections and cannisters to build the streamer from 3 to 4 km. The weather is cold and rainy with winds up to 40-50 kts. Science meeting at 1830L to go over general cruise plan.

23 March 1991 (Sat) - Continued through " inside passage"; weather cold and rainy but clears by late afternoon. In early evening we have to swing out around Taito Peninsula into the open ocean. Seas are quite rough.

24 March 1991 (Sun) - By early morning we are back in the passage; weather is sunny and calm. Beautiful scenery! P. Henkart has the Sun Sparcstation 1+ on the *Ewing* network and is now running SIOSEIS. He also can send plots to the laser printer. Lab orientation at 1300L; lab watch was started and ran till midnight, then was restarted the following day after the pilot was dropped off.

Two issues regarding ESPs came up. The longest records the DDS 240 can record are 20 s and it requires about 1.2 s to cycle for the next record. Therefore to record 40 s ESP records two consecutive 20 s records will have to be recorded, but there will be a 1.2 sec gap in the middle. To avoid a problem we may introduce a recording delay for the larger offset shots (e.g. no delay out to ranges of 30 km; 5 s delay from 30-60 km). This will have to be done on a time basis; i.e. a delay of 5 s for the first 1.5 hr of the ESP; none for the middle 3 hr of ESP and 5 s delay for the last 1.5 hr. For the short ESPs no delay will be used.

J. Mutter suggested recording a low-fold CDP line during the ESPs by shooting once during the last 20 s of each minute. Thus nominally *Washington* will shoot on the 1st sec of each minute; *Ewing* will record for 40 s; *Ewing* will shoot on the 40th second and record for 20 sec; then the cycle will repeat.

25 March 1991 (Mon) - We anchored off of Ancud, Chile at about 0930L, offloaded the pilot, went through customs (again!) and transferred a number of streamer sections and cannisters to the *Ewing*. The whole process took until early afternoon. We then set sail for the EPR near 20.7°S. The transit will take ~9 days. Weather is beautiful.

26 March 1991 (Tues) - Underway to EPR. Weather sunny and calm; making 11 kts. Began to work on building an additional 1000 m on the streamer. We filled four 100 m sections with oil and added them to the existing 3 km of streamer on the reel. Hydrosweep performance once we got into relatively deep water (~4 km) is poor with significant beam drop outs and large numbers of "divots", as seen on previous legs. In one case it lost bottom altogether and had to be reinitialized. Overheating of the circuit boards in the main cabinet may be a problem; this door is now tied open and the engineers will pipe in extra air conditioning to this part of the lab.

27 March 1991 (Wed) - Underway to EPR. Cloudy this am, but clear by late afternoon. Light wind, almost no sea or swell. Making 11.5 kts; at this speed we will reach EPR in the early hours of April 3rd (next Wed.). Continued streamer work adding six 50-m sections. Met with Captain and Chief Engr. to go over procedures during MCS operations. All three LMF compressors are now in pieces, but should be ready in time. Hydrosweep performance is poor-to-

awful. We have started a log of the console settings for future reference. Generally we have followed the guidelines of the other legs - i.e. a slope qualifier of 50%, manual window positioned just below the depth of the outer beams, disabled the automatic sound velocity calculation. The Magnavox MARSAT receiver is down; no e-mail since Monday.

28 March 1991 (Thurs) - Underway to EPR. Great weather continues; almost no wind or swell; mylar seas. Finished streamer work adding six more 50-m sections to the streamer on the reel and 4 spares. Streamer fails to build; fault at slip ring. Jim D. is worried about the VAX site licenses expiring; he's waiting for the word from URI to update licenses. He may have to backdate system clock. Still no e-mail.

29 March 1991 (Fri) - Underway to EPR. Passed through a small front this morning; winds kicked up to 20 kts or so with light rain. While attempting to install the SCSI cable from Cipher tape drive to the Sun workstation the Fujitsu hard disk crashed when it was moved (it had not been turned off). The disk came up again but critical parts of the UNIX system files had been damaged. Without a boot disk or another Sun aboard there is no easy way to reboot the disk. Our only hope is that a boot disk can be transferred from the *Washington*. The streamer was successfully built today, but a problem remains with the slip ring. The Magnavox MARSAT receiver was fixed by mid-day and e-mail is up again.

30 March 1991 (Sat) - Underway to EPR. Weather is excellent. All three LMF compressors have now been re-built and are up and running. Received a message from Orcutt that the *Washington* left on time and is making 12.5 kts on its trek south. Hydrosweep performance is awful - only 30-50% of data being collected is useable, generally only the innermost 16 beams. On the cross-profile display one often sees two spurious troughs centered on beams 10-21 and 38-49 flanking the apparently valid depths on beams 22-37 (innermost beams) producing a "double-tunnel" effect in the contoured bathymetry. S/N on outer two-thirds of swath is often <10. Sent Dale Chayes e-mail describing the seriousness of these problems.

31 March 1991 (Sun) - Easter, 1991. Still underway to EPR. Weather is excellent. Joe Stennett ran some diagnostic tests on Hydrosweep this am; found power output of some transducers was zero but later determined that this was due to a bad power output monitor. Around 0000Z 1 April the Hydrosweep system crashed completely and we were unable to reboot it - couldn't find bottom. Lab was unusually hot at the time (78°C); we don't know whether this was a factor. Hydrosweep back on around 0400Z.

1 April 1991 (Mon) - Still underway to EPR. Hydrosweep crashed again this am. For the past 2-3 days Hydrosweep has been effectively inoperative.

2 April 1991 (Tues) - Still underway to EPR. Hydrosweep is better today; probably because we are over shallower, unsedimented sea floor. One crash this pm when Hydrosweep lost the

bottom, but otherwise it has been working well.

3 April 1991 (Wed) - At 0945Z we slowed down for streamer deployment. The tailbuoy went in the water at 1050Z. The streamer is 4 km long and has 160 channels with 25-m groups. It has a 100 m passive isolation section and two 50 m stretch sections; the distance to the near-offset channel is 250 m. The airgun array we will shoot consists of 20 airguns totaling 8385 cu. in. in four main subarrays. The guns are numbered from starboard to port:

Port																			Starboard
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
145	825	260	350	520	350	250	850	500	145	145	540	850	250	350	520	305	235	850	145

The initial deployment went as smoothly as could be expected and was completed about 1934Z. However, the streamer was too buoyant and floated at the surface. It had been filled with oil appropriate for the preceding Antarctic leg where sea surface temperatures are ~20°C colder than where we are working. The streamer was recovered to let oil out of some sections, particularly the 100-m sections and the large diameter 50-m sections. We ended up letting out as much as 8 gal. of streamer oil per 100-m section.

4 April 1991 (Thurs) - Streamer deployment and balancing continued. We encountered an unusually large number of leaks, especially on the inner wraps. The digitizing cans and the metal slip rings on interconnectors are puncturing the streamer skin, especially near section bulkheads. This problem is probably being exacerbated by the additional weight of the extra 1000 m of streamer added for this leg and the softness of the streamer jacket in warm water. Final deployment was not completed until ~0600Z 5 April; the whole operation took almost 2 days.

5 April 1991 (Fri.) - Shooting began at 1007Z at about 20°37.9'S near the southern end of the segment G at the 20.7 S propagator (see Fig. 3). SEPR-1 runs along the rise axis north to about

20°10'S where a short (~20 km) line (SEPR-2) was run across the rise axis. SEPR-3 began at 0137Z (6 April) and runs along the rise axis north to 19°25'S where another short cross axis line was run (SEPR-4). A strong sub-horizontal reflector was observed 450 ms below the sea floor (~1 km depth) near latitude 19°35'S on the single channel monitor records. This is somewhat shallower than the typical depth of the AMC event along the northern EPR.

Hydrosweep is performing superbly while running *along* the rise axis - noise artifacts and beam dropout problems are minimal and, as long as the electronic cabinet is kept cool, system crashes have not occurred. The combination of shallow water depths (< 3000 m), slow speeds (5 kts), and no sediment appear to be to its liking. The Hydrosweep console with its color-filled map and the cross-profile displays has been invaluable for our along-axis profiling. However, as soon as one gets more than 5 or 6 km from the rise axis (on lines either parallel or perpendicular to the rise axis) the noise problems which plagued our transit reappear.

6 April 1991 (Sat.) - Continuing to work our way north along the EPR towards 17°20'S where the two-ship work will commence. Began shooting SEPR-5 at 1905Z. This line runs along the northern half of segment G, through the OSC at 19°S, then north along segment H to the 18°37'S OSC (Fig. 3). Segment H is a poorly mapped ridge segment with a shallow ridge lying immediately to the east that previously has been misinterpreted as the rise axis. Segment H is associated with a broad (~2 km), deep (>2800 m) axial dome, without an obvious axial rift, that gradually shoals to the north reaching depths of less than 2700 m just south of the 18°37'S OSC. The northernmost part of Segment H (18°40'S to 18°37'S) is associated with a strong axial reflector. This is a little surprising since this part of the ridge is almost adjacent to the 18°37'S OSC, although it is the shallowest part of this ridge segment. The depth of the AMC reflector decreases from about 650 ms below the sea floor to ~450 ms below the sea floor as the rise axis shoals. At the 18°37'S OSC we looped around to the east, crossing segment H at about 18°38'S, then heading north along Segment I (we did not stop shooting during the turn so this will all be SEPR-5).

7 April 1991 (Sun.) - Continued shooting SEPR-5 along the axis of Segment I. This is the so-called "Hump Region" of the southern EPR with axial depths less than 2600 m. Segment I (18°37'S-18°22'S) is characterized by an axial graben about 1 km wide and 50 m deep. Sinton et al. report that this segment is characterized by relatively more differentiated lavas than the segments to the north and south as well as a more extensive sediment cover. Single channel monitor records indicate a strong reflector beneath the axial rift lying ~550 ms below the sea floor. A short line (SEPR-6) shot across this segment at latitude 18°28'S suggests the axial reflector is quite narrow and centered beneath the axial rift, not below the higher eastern shoulder of the axial high. Line SEPR-6 was completed at 1625Z.

SEPR-7 started at 1914Z and ran up the rise axis along the northern half of segment I, across the 18°22'S OSC, and along segment J to ~18°12.0S. A particularly strong AMC event was observed along segment I about 500 ms below the sea floor. A similar event was seen along the central part of segment J about 600 ms below the sea floor. In both cases the MCS profile was run along what appears to be an axial graben. Segment J is notable for a very broad (>3 km wide) dome-shaped axial high, and according to Sinton et al. (1991), relatively undifferentiated lavas. Line SEPR-7 was ended at 2231Z.

P.Henkart finally got SIOSEIS working today after a long delay following the crash of the Sun Acropolis disk drive last week. He reads the DSS-240 tapes on a 6250 bpi Cipher tape drive, runs SIOSEIS on a Masscomp, transfers the files to a Silicon Graphics Iris workstation and sends the plots from there to a Printronix printer via a serial port on the Silicon Graphics!! What a work-around! He initially plotted some shot gathers to QC the streamer. An example of one of these plots is shown in Figure 4.

8 April 1991 (Mon.) - SEPR-8 was run across the rise axis at approximately 18°13.5'S, near the middle of segment J. This line began at 0114Z and was completed by 0342Z. After turning back onto the EPR crest, SEPR-9 was begun at 0625Z. This line runs north along what appears to be a shallow, broad axial graben on segment J, across the ridge axis discontinuity at 18°S, then north along the axis of segment K. The 18°S ridge offset is rather odd; certainly not a typical OSC. The eastern high of segment J continues well to the north then curves to the east *away* from segment K. We had trouble locating and running along the rise crest on the southernmost section of segment K. North of 17°50'S, however, segment K develops into a broad, extremely linear dome-shaped axial high that was easy to follow. At 1605Z we had a streamer telemetry error around Can 17. The acquisition system was down for 34 minutes resulting in a data gap along the rise axis between 17°27.3'S and 17°24.5'S, coincidently the shallowest part of this ridge segment. Another system crash occurred at 1800Z lasting for 7 minutes (data gap between 17°17.5'S and 17°18'S). The data telemetry problem appears to located at or around Can 17. SEPR-9 was completed at 2129Z and we then slowed and began to recover the streamer for repairs.

9 April 1991 (Tues.) - We spent a total of about 14 hours recovering and redeploying the streamer, finishing about 1230Z. During recovery we taped rags around the connectors, adapter sections and cans to prevent them from cutting the skin of the streamer when it was wrapped on the reel. We had three sections destroyed by shark bites during the recovery and had to replace them. To avoid further shark damage to the streamer we steamed several miles away before continuing the operation. We discovered evidence for a leak in the connector just forward of Can 18, possibly the source of the original problem. During redeployment we swapped out a number of cans and sections.

This area, between about 17°05'S and 17°35'S, is the location of the first of three detailed surveys planned for the SEPR experiment. The locations of the CDP reflection profiles and ESPs obtained in this area are shown schematically in Figs. 5 and 6. After completing the streamer redeployment we shot the northernmost of the eleven cross-axis CDP lines in this area. This profile, called SEPR-10, crosses the ridge axis at ~17°04'S (Fig. 5). This line was shot using a 10 s shot interval using alternative halves of the airgun array. The streamer looks good. Shot gather plots indicate 6 bad traces out of 160 (141-144 and 105 are dead, and trace 2 has large, intermittent noise spikes).

While we worked on the streamer and during the shooting of SEPR-10, *Washington* completed the deployment of six OBS near the center of the ESP area. Locations of the OBS are given in Table 2. At about 1600L we met the *Washington* to transfer airgun chambers, a VHF radio, sonobuoys and some other equipment prior to commencing the ESP work. Orcutt and Harding came over to *Ewing* for a brief review of plans and procedures for the two ship work. The transfer was complete by 1800L and we steamed for the start of SEPR-11, another profile across the EPR at 17°09'S.

<u>10 April 1991 (Wed.)</u> - We began SEPR-11 at 0401Z and it was completed at 1003Z. This profile was shot using the full 8385 cu. in. airgun array fired every 20 s; 18.75 s records were recorded. After finishing this line we steamed for the northern start point of ESP 1 (SEPR-12) on the western flank of the EPR (Fig. 6). This line began at 1330Z. During this ESP *Washington* fired a 2600 cu. in. airgun array (760, 640, 550, 300, 200, 150 cu. in.) on each minute. For ranges less than 30 km *Ewing* recorded two 18.75 s windows (from second 1 to 20; then second 21-40) then *Ewing* fired on second 40 and recorded its own shot from second 41-60. For ranges greater than 30 km a 5 sec recording delay was introduced (that is, *Ewing* recorded three 20 s windows beginning on seconds 5, 25 and 45, and shot on second 45). Appendix 3 includes the *Ewing-to-Washington* bearing data for each ESP crossing.

ESP 1/SEPR-12 began at 1332Z and was completed at 2003Z. This ESP is located 10 km west of and parallel to the EPR crest and was shot out to ranges of 60 km (see Fig. 6). The differential GPS receiver on *Ewing* was not working during this entire ESP and no data were logged. Shot gather plots were monitored and no arrivals were observed beyond ~15-20 km range. ESP 2/SEPR-13, located 6 km west of the rise axis, was begun at 2142Z and completed at 0321Z (11 April). The incoming half of this ESP was handicapped by the loss of both the 760 and 550 cu. in. airguns on *Washington*; the outgoing half went well although the 760 was lost again for the part of the line. *Ewing* deployed a sonobuoy at 2254Z (SB#13).

On this and all subsequent ESPs the Master of the *Washington*, Captain Desjardens, insisted on port-to-port crossings, even when their ship approached the midpoint well on *Ewing's* starboard bow. This necessitated a radical course change, usually carried out at about 2 nm ship-to-ship range, to bring *Washington* across our bow for a port-to-port crossing. Captain Desjardens also insisted on 0.5 nm minimum CPA, except for a few rise axis ESPs when with special pleading he agreed to a 0.25-0.3 nm CPA. These unnecessary maneuvers will severely complicate the processing and interpretation of the short-range ESP information

11 April 1991 (Thur.) - ESP 3/SEPR 14, located just 3 km west of the rise axis, was begun at 0455Z. The 550 cu.in. airgun went down on *Washington* just before the midpoint (0620Z) and was back on line by 0700Z. On the outgoing half of the ESP *Washington* continued to have gun problems. The 760 gun went down at 0734Z and by 0820Z only the 550, 200 and 150 cu. in. airguns were still firing. By 0839Z all the guns except the 760 were firing; the ESP was completed at 0926Z. Because of the airgun problems on *Washington*, it was decided to postpone the critical rise axis ESP (ESP 4) and do ESP 5 (located 3 km east of the rise axis) next. This line, ESP 5/SEPR-15 began at 1311Z and almost immediately (1318Z) *Washington* had gun problems, this time with their firing control box. It was repaired and they resumed shooting at 1424Z. However, when the recording delay was switched from 5 to 0 s at 1411Z, the *Ewing* airguns began to incorrectly fire at the same time as the *Washington* guns. This problem was not corrected until just before the midpoint at 1517Z - the incoming half of ESP 5 is effectively a total loss. The outgoing half of the ESP went smoothly and the ESP was completed at 1735Z.

We decided to complete ESP 6 next followed by ESP 4 (on the rise axis) in order to provide an port-to-port crossing for *Washington* on the rise axis. On *Washington* they decide to pull the 760 cu in airgun from their array and replace it with a 550. Their airgun array thus now consists of six guns with the following chamber sizes: 640, 2x550, 300, 200, 150. ESP 6 SEPR-16 began at 1902Z and went smoothly except for one short period between 2215 and 2219Z when *Washington* fired at the same time as *Ewing*. ESP 6 was completed at 0032Z.

12 April 1991 (Fri.) - ESP 4/SEPR-17, run along the crest of the EPR, was begun at 0150Z. Sonobuoy #15 was launched at 0157Z. An extremely bright axial reflector was observed for about 3 km along the rise axis near 17 °26.3'S (0255Z). This is the location where we had a data gap in SEPR-9, the CDP reflection profile run along the rise axis. On the incoming part of the ESP *Washington* lost a 550 cu. in. airgun at about 20 km shot-receiver range (probably the worst spot for interpreting the shadow zone of an axial LVZ!). The midpoint was at 0432Z with *Washington* passing within 0.3 nm of *Ewing*. The outgoing half of ESP 4 went very well - no gun failures on *Washington* and no recording problems on *Ewing*. A second sonobuoy was launched at 0531Z. ESP 4/SEPR 17 was completed at 0713Z. The ships then turned to begin ESP 7, located 10 km east of the rise axis. ESP 7/SEPR-18 began at 0932Z and almost immediately we ran into problems with the source array on *Washington* as they lost one or both of their 550 cu. in. airguns

twice (1115-1118Z; 1225-1226Z). On *Ewing* the recording system crashed at 1132Z and several shots were missed. The outgoing half of the ESP was finally aborted at 1407Z due to a complete failure of the *Washington's* gun firing unit.

At this point we decided to pull in the streamer and replace Can 36 (which had not been functioning since the last deployment) while the *Washington* worked on its gun system. Streamer deployment and recovery went smoothly and was completed in about 2 hours. ESP 8/SEPR-19, located 14 km east of the rise axis, was begun at 1839Z. *Washington's* airguns worked well throughout this ESP; the 640 cu. in. airgun was down for only 45 min between 1945Z and 2030Z. Two seamounts were encountered on this ESP; the line crossed directly over a 250 m high seamount near 17°10.5'S and skirted the western flank of a much larger seamount near 17°30'S. This line was completed at 0105Z (13 April). During the turn onto the next line the strain gauge on the streamer broke, causing a brief moment of panic. But all was ok - the wire to the strain gauge apparently got caught on the streamer level wind.

13 April 1991 (Sat.) - ESP 9/SEPR-20, located ~18 km east of the rise axis, was started at 0203Z. The southern half of this ESP passes over a large (500 m high) seamount near 17°30'S. This line was run without incident with the exception of a 13 minute period between 0732Z and 0745Z when the *Washington* gun firing unit was firing intermittently. ESP 9 was completed at 0842Z. ESP 10/SEPR-21, located nominally 25 km from the rise axis, was shifted about 2 km to the east to avoid a small seamount located near the midpoint. ESP 10 was begun at 1022Z and completed at 1646Z. Despite repositioning this line it still crossed the western flank of a large seamount (>700 m high) near 17°19'S. These small near-axis seamounts do not appear to have any obvious orientation and are quite abundant in this area. The recording system crashed three times during this run, but only a few shots were lost each time.

After completing ESP 10 we turned west toward the rise axis to run three short (~20 km maximum offset) ESPs on the rise axis. The first of these (ESP 11) had a midpoint at 17°09.5'S; and two others were shot with midpoints at 17°14.7'S (ESP 12) and 17°26.3'S (ESP 14), respectively. ESP 14 was shot over a portion of the rise axis with a very bright, shallow AMC reflector. ESP 11 was run from 2125-2336Z; ESP 12 from 0140-0357Z (April 14). On ESP 12 we had some problems with the recording system and several shots were missed, especially between 0330Z and 0338Z. These problems were later traced to the ship's radio officer using his ham radio which interfered with timing pulses on the DSS-240. His transmissions were stopped.

14 April 1991 (Sun.) - ESP 13 was oriented perpendicular to the rise axis at 17°20'S through a line joining the midpoints of all the axis-parallel ESPs. Both ships began 10 km from the rise axis and shot out to a point 20 km from the rise axis. ESP 13 (SEPR-24) began at 0752Z and was completed at 1113Z without any problems. The completion of ESP 14 at 1706Z finished 4 days of

two ship work in SEPR Area 1. The *Washington* immediately began to recover its 6 OBS while the *Ewing* started shooting the remaining cross-axis CDP lines planned for this area. All six OBS were successfully recovered but it was discovered that two of the instruments (Karen and Sharyn), both deployed west of the rise axis, failed to record data. The cause of this failure could not be immediately determined.

One note about the timing of the recording window for *Washington's* shots during the ESPs. For ESPs 1-6 there is about a 0.874 s delay between the *Washington's* shot time and the start of the recording window on *Ewing*. That is, time zero on the shot record corresponds to a true time of about 0.874 s (the exact value varies from shot-to-shot and was recorded). Beginning with ESP 7 this delay was adjusted to be 0.074 s.

15 April 1991 (Mon.) - During Sunday evening and the wee hours of Monday morning we shot 5 short (~20 km long) CDP profiles across the rise axis (SEPR-26 to 30). The first two short cross-axis lines were located just north and south of the axial topographic high at 17°26.3'S, while SEPR-28 and 29 crossed the rise axis at the location of the two Scripps OBS deployed on the rise axis (Fig. 5). These lines were all run using the full 20-gun array firing every 20 s. Some minor problems were encountered with tape drives and system timing problems, but otherwise these lines went very smoothly. SEPR-30 was completed at 1141Z and we then began shooting four long (~50 km) cross-axis profiles (SEPR-31 to 34), working from north to south through the area. SEPR-31 and 34 were shot at 10 s with the 10-gun array while SEPR-32 and 33 were shot using the full 20-gun array firing every 20 s (on SEPR-31 the first 49 minutes of the line was shot at 20 s before changing to the 10 s firing mode). Some minor problems continued to be encountered with system timing during these lines. The recording cycle start time ranged from 0.874 to 0.074 and varied from shot to shot.

16 April 1991 (Tues.) - We continued shooting the remaining cross-axis reflection profiles in the 17°20'S area while the *Washington* redeployed its OBS at the 15°55'S OSC. SEPR-33, which crosses the rise axis at 17°26.3'S was the most interesting of these profiles showing on the single channel monitor records both a narrow AMC reflector ~500 ms below the sea floor. This part of the rise axis was also characterized by an exceptionally strong AMC event in the along axis CDP profile collected during ESP 4 (SEPR-17). The last of these lines, SEPR-34, was completed at 2051Z. We then began a long, along-axis CDP profile (SEPR-35) from about 17°32'S to the 15°55'S OSC. SEPR-35 was shot using the full 20-gun array firing at a 20 s interval. The part of this line between 17°32'S and 17°03'S can thus be directly compared with SERP-9 which was shot with the alternating 10-gun array firing every 10 s.

17 April 1991 (Wed.) - Continued running SEPR-35 north along the rise axis of segments K and L to the 15°55'S OSC. On the first part of this line we had trouble keeping the streamer down;

it was briefly at the surface at 0115Z, again at 0420Z and once more at 0655Z. Four sonobuoys were launched along this line (SB#22-25). A strong AMC reflector was observed near 16°55'S. The rise axis near the OSC is a very narrow, steep-sided axial block in contrast to the broad, domal shape of the rise axis further to the south. SEPR-35 was completed at 2339Z, after which we began a suite a 9 CDP profiles across the 15°55'S OSC and the adjacent ridge crests. While we were shooting SEPR-35, the *Washington* redeployed its six OBS in this area. The OBS locations are given in Table 2.

18 April 1991 (Thurs.) - Figure 7 shows the location of the nine cross-axis CDP profiles shot in the 15°55'S OSC area and the positions of the Scripps OBS. Three profiles (SEPR-36,37 and 38) cross the northern ridge crest (segment M) approximately 28 km, 16 km and 8 km from the overlap basin, respectively. Three complementary profiles (SEPR-42,43 and 44) cross the southern ridge axis (segment L) a similar distance from the OSC. Three lines (SEPR-39, 40 and 41) cross the overlap basin. All the profiles are nominally 20 km long with the exception of SEPR-40 which is 30 km long. SEPR-40 crosses three of the Scripps OBS deployed in the OSC. All these lines were run with the full 20-gun array firing every 20 s. The first of these lines, SEPR-36, was begun at 0049Z and the last line (SEPR-44) was completed at 1228Z (April 19). No major problems were encountered. After finishing this line we turned northeast to pick up the southern end of the northern ridge segment and began shooting SEPR-45 north along the axis of the EPR at 1315Z.

19 April 1991 (Fri.) - Continued shooting SEPR-45 along the axis of segment M north of the 15°55'S OSC. Segment M has a remarkably narrow (2 km wide at its base), triangular-shaped axial high about 350 m high with a summit that is only 200-300 m wide. Sonobuoys were launched about every 2 hours (20 km) along SEPR-45 (SB#27-33). A very common morphological feature observed along this part of the EPR are lobate bathymetric highs extending flankward from the rise axis. They appear to be major lava flows that have spilled down the flanks of the axial high. A particularly good example of one of these features is at about 15°20'S. This flow (or flows) extends ~1 km from the rise axis and appears to be >50 m thick.

20 April 1991 (Sat.) - Continued shooting SEPR-45 along the axis of segment N north of the large 15°S Deval. Morphologically segment N is broader at its base (~4 km) and not as high (<200 m) as segment M, with a relatively wide (~1 km) flat topped summit. The axial depth is remarkably constant at 2650 m along most of its length. Between 14°25'S and 14°10'S this part of the EPR is characterized by a very strong AMC event about 500 ms below the sea floor. This value is typical of most of the southern EPR we have surveyed on this leg and is consistent with a lid thickness above the AMC of only about 1 km. This compares with typical values of 600-700 ms for the AMC event at 9°N and lid thicknesses of ~1.6 km. J. Orcutt reports that preliminary

analysis of the OBS data from the 17°20'S area suggests a thinner layer 2 at the rise axis which is consistent with the reflection results.

SEPR-45 was completed at 1634Z. With the exception of a failure of a compressor cooling motor between 1230 and 1237Z and a few shots lost to recording system crashes no significant problems were encountered running this profile. While *Washington* redeployed their OBS in the 14°15'S south area, we steamed east to complete the northernmost cross-axis CDP profile (SEPR-46) before beginning the ESP work in this area. Figures 8 and 9 show the location of the CDP reflection profiles and ESPs obtained in the 14°15'S area. Scripps OBS positions are also shown and are listed in Table 2.

21 April 1991 (Sun.) - After finishing SEPR-46 at 0127Z we began the first of 9 ESPs planned for the 14°15'S area. As was the case in the 15°20'S area, *Washington* fired a 2600 cu. in. airgun array (760, 640, 550, 300, 200, 150 cu. in.) on each minute, while *Ewing* recorded a low-fold CDP line by shooting once a minute on the 40th second of each minute. There was some concern that reverberations from the *Ewing* shots may be obscuring the *Washington* arrivals but shot gather plots from earlier ESPs showed no evidence of this. Shooting began with the westernmost ESP and proceeded from west to east (Fig. 9).

ESP 15 (SEPR-47) was begun at 0313Z and completed at 0939Z. This ESP had a number of problems. The line crossed a large (>400 m) seamount near 14°08'S. The *Ewing's* recording system was down from 0733-0751Z (~1-1 1/2 hrs after the midpoint) due to a bad time block; later at about 0810Z *Ewing* began firing at 20 sec past the minute rather than 40 sec past the minute. Shot gather plots for ESP 15 also indicated a large time shift (2-3 sec) for the *Washington* arrivals. We spent the better part of a day tracking this problem down. It was finally traced to a problem with the synchronization of the GOES-West clock used on *Washington* to fired their guns with the GPS clock used to trigger recording on *Ewing*. Occasionally, the GOES-West clock jumps a second or more out of synch with "true" time and it can sometimes be several hours before this offset is corrected. This problem may exist on other ESPs too. Apparently both GEOS-West time and GPS time are being logged on *Washington* so these timing errors are recoverable, but they will complicate ESP processing to say the least.

ESP 16 (SEPR-48) located ~14 km west of the rise axis was begun at 1202Z and completed at 1917Z. This ESP went smoothly; the only problems were a recording system crash at 1500Z during which five shots were lost and a period of 42 minutes between 1745Z and 1837Z when the 200 cu. in. airgun on *Washington* was out of service to replace a bad O-ring.

22 April 1991 (Mon.) - We continued shooting ESPs in the 14°20'S area. ESP 17 (SEPR-49) and ESP 18 (SEPR-50), located 6 and 3 km west of the ridge axis respectively, were shot between 0455Z and 1544Z. The topography on both lines was quite smooth and extremely two-

dimensional. We then shot ESP 20 (SEPR-51), 3 km east of the rise axis in order to position *Ewing* to run ESP 19 (on the ridge axis), from south to north. This is the optimal direction for a port-to-port crossing, which the Master of the Washington continues to insist on. ESP 19 (SEPR-52) was successfully completed between 1724Z and 2036Z.

23 April 1991 (Tues.) - ESP 21 (SEPR-53), located ~6 km east of the rise axis, was completed next. *Washington* lost their 760 cu. in. airgun for 25 minutes (0014-0039Z) only about an hour after the line began, but otherwise this ESP went smoothly. In order to save time, we decided to shoot only the inbound half of ESP 22 and the outbound half of ESP 23. These lines were completed at 1441Z. At this point the *Washington* started recovering its OBS while Ewing shot two long cross-axis profiles in the southern part of the 14°20'S area. On SEPR-56, which crossed the rise axis near 14°24.5'S, a recording system crash occurred for 13 minutes right at the ridge axis (1853-1906Z). The second line (SEPR-57) crossed the rise axis near 14°29.3'S. It also experienced a short recording gap just after crossing the rise axis due to a similar system crash. This line was cut short at 0400Z (24 April) in order to meet *Washington* for a long wide aperture profile along the rise axis.

24 April 1991 (Wed.) - At 0600Z we began shooting the wide aperture profile north along the rise axis from 14°30'S to about 13°31.5'S. The objective of this line, designated SEPR-58/W1, is to continuously map the uppermost crustal structure down to the axial LVZ along a substantial length of the EPR. *Ewing* was the lead ship for this profile with *Washington* following 4 nm (7.4 km) behind creating a synthetic aperture of approximately 7.5 km. *Ewing* and *Washington* shot alternatively every 20 s; *Washington* fired its normal 2850 cu. in., 6-gun array while Ewing fired 6 guns designed to match as closely as possible the *Washington* source. The guns used had chamber sizes of 850, 540, 500, 350, 235 and 145 cu. in. and totaled 2620 cu. in. *Washington* stopped shooting at 1700Z and we stopped recording at 1712Z. This completed all two ship operations. After a short rendezvous with the *Washington* to return some equipment to the *Ewing* and to transfer Paul Henkart to the *Washington*, they departed at ~1100Z for Manzanillo. After they left we continued shooting north along the EPR to the Garrett transform. This line, SEPR-59, was shot with the full 20-gun array firing every 20 s. It was completed at ~2214Z. We then immediately turned to begin a CDP reflection profile (SEPR-60) back down the EPR to the 14°20'S area to complement the wide aperture line.

25 April 1991 (Thurs.) - SEPR-60 began at 2337Z (24 April) and was completed at 0534Z. It runs from just north of the Garrett transform, crosses the western ridge transform intersection and runs south along the rise axis to 13°49.5'S (Fig. 3). At this point a short (20 km) cross-axis profile (SEPR-61) was run across the ridge axis. After this line was completed we continued to shoot south along the rise axis to about 14°S. This line (SEPR-62) was completed at 1509Z.

Minor, but increasingly frequent recording system crashed occurred on all of these lines. A faulty power supply cable was found at the back of the DDS-240 control unit and replaced. With the completion of SEPR-62 we began a series of 6 short (20km) cross-axis lines in the 14°15'S ESP area (lines SEPR-63-68; see Fig. 8).

26 April 1991 (Fri.) - Continued shooting the short cross-axis CDP profiles. We are still having problems with frequent DSS-240 system crashes. Joe Stennett reduced the record length from 18.75 to 18 s beginning on line SEPR-65, but this did not solve the problem (by specifying a shorter tape length Emilio did appear to succeed in eliminating a problem with the DSS-240 writing short tapes). The last of the short cross-axis profiles was completed at 1742Z. We then began to shoot the remaining 4 long (>50 km) cross-axis profiles planned for this area.

27 April 1991 (Sat.) - Completed shooting cross-axis profiles SEPR-69-72. SEPR-69 and 71 were shot at a 10 s rep rate; SEPR-70 and 72 at 20 s. During SEPR-70 gun 13 went down (~1030Z). It was decided to take the chamber from gun 13 and put it in gun 11, firing effectively a 19-gun array for the remainder of this line and SEPR-71 and 72. All four of these lines show good axial reflectors. SEPR-70, which crosses the EPR near 14°15'S, in particular has a very high-amplitude, relatively wide (>1.5 km) AMC reflector beneath the axial summit. This event is clearly phase-reversed and is only 420 ms below the sea floor, one of the shallowest AMC events we have seen anywhere along the EPR.

28 April 1991 (Sun.) - SEPR-72 was finished at 0347Z completing MCS operation on EW 91-02. Streamer recovery began immediately and the tailbuoy was aboard by 1245Z The recovery went fairly smoothly but we continued to have problems with about a dozen leaky sections caused by punctures or cracks in the streamer jacket. Some of these occur as the streamer is being recovered and can be patched, but others occur after the section is wound on the reel (despite padding all connectors and cans with rags). This is a time consuming nuisance that will have to be addressed soon. Inspection of the tailbuoy revealed that the "water-tight" compartment for the GPS receiver was full of water. It probably had flooded within hours of deployment. After the streamer was aboard we headed for Tahiti, 2160 miles and 9 days away.

29 April - 6 May 1991 - Continued transit to Tahiti. On Tuesday (30 April) we spent about 9 hours deploying and recovering the streamer in order to find out why it would not build beyond Can 23. Diagnostics suggested a problem with Can 23 or section 24. The streamer was deployed to this point and Can 23 and section 24 were replaced, but the streamer still would not build to Can 1. Joe Stennett suspected the problem was a partial short somewhere aft of Can 23. The streamer was recovered and broken every 4th can to track down the short. During this process we replaced two leaky sections with spares. A short was finally found in a connector on section 9. However, after replacing this connector the streamer still would not build and diagnostics indicated a problem

at Can 23 or 24.

The maggy was recovered and secured at 1730Z on May 3rd as we approached the Tuamotu archipelago. The lab watch was finally stopped on May 6th at 1800Z. At this point we spent about 7 1/2 hours deploying and recovering the streamer yet again to track down why it wouldn't build beyond Can 24. Cans 24, 25 and 26 were all replaced, and 400-m of section between Can 23 and 27 were moved to the tail end of the streamer. Can 26 may have been the problem; after it was swapped out the streamer built without any problems. One other water-filled section was replaced and several leaks were repaired. These operations were finished at 0130Z (7 May). After a short test to determine the *Ewing's* station keeping capabilities, we got underway for Papeete.

7 May 1991 (Tues.) - Arrived in Papeete, Tahiti at ~0830L (1830Z) ending EW 91-02.

5.0 Preliminary Results

EW 91-02 collected an enormous seismic data set on the crustal structure of the EPR south of the Garrett fracture zone. These data include continuous along-axis CDP reflection coverage of more than 700 km of rise axis from 20.7°S to the Garrett transform, 38 CDP reflection profiles across the EPR primarily concentrated in three detailed survey areas located at 17°20'S, 14°15'S and the 15°55'S OSC, and 23 ESPs in the 17°20'S and 14°15'S areas. In addition, thousands of shots from Ewing's powerful 8400 cu. in. airgun array were recorded by 6 Scripps OBS in each detailed survey area during the CDP and ESP operations. Hydrosweep bathymetric data, gravity and magnetics were also recorded throughout the study.

Single channel monitor records and low-fold stacked sections produced by the shipboard processing system set up by Paul Henkart allow us to draw some preliminary conclusions about the existence and dimensions of crustal magma bodies along this part of the EPR. A large amplitude, shallow, intra-crustal reflector is observed on both along-axis and cross-axis reflection profiles that is similar to the event documented along the northern EPR and interpreted as a reflection from the top of an axial magma chamber (AMC). This reflector is strong enough in some areas that it is seen on single channel monitor records (see Figs. 10 and 11) as well as in stacked data, especially on along-axis profiles. Portions of the rise axis with particularly strong axial reflectors include 14°S - 14°25'S, near 15°S, 16°55'S, 17°26'S and 18°30'S, in the so-called Hump Area between 18°22'S and 18°37'S, immediately south of the 18°37'S OSC, and near 19°35'S. Although an AMC event is common in our data, it is by no means ubiquitous and there are significant sections of ridge where no AMC reflector is apparent, at least in the single channel monitor records. Reshooting of selected ridge segments using airgun arrays with volumes ranging from 2600 cu. in. to 8400 cu. in. indicate that our ability to image an AMC event is not source dependent. The along-axis variations seen in the amplitude of the AMC event must reflect, to some extent, real along-axis variability in the magma chamber or along along-axis variations in sea floor reflectivity/scattering characteristics.

Low-fold stacks of two representative cross-axis CDP profiles (SEPR-28, SEPR-70) are shown in Figures 12 and 13; a portion of an along-axis profile (SEPR-45) is shown in Figure 14. SEPR-45 and 70 are both located near 14°15'S; SEPR-28 crosses the rise axis at about 17°22'S. All three profiles have been stacked at a constant velocity of 2200 m/s using only the innermost 24 traces of the 160 channel streamer (offsets < 1 km). The 2200 m/s stacking velocity has been chosen to enhance shallow crustal reflectors, like the AMC event. SEPR-28 and 45 are 6-fold stacks; SEPR-70 is a 12-fold stack. Both have been filtered 6-40 Hz. The AMC event seen in these profiles is quite similar in character to the reflector mapped along the slower spreading northern EPR. A narrow, relatively flat-lying event is present beneath the rise crest and this reflector can be followed as a very continuous horizon along the rise axis. The width of the reflector ranges from < 1 km on SEPR-28 to ~1.7 km on SEPR-70. These widths are comparable to what was observed on the northern EPR and suggest that there is not a significant spreading rate dependence to magma chamber size as predicted by many ridge crest thermal models. The depth of the AMC event is, however, somewhat shallower along the southern EPR than it was in the 9-13°N area. Along the northern EPR the AMC event is typically located 600-700 ms below the sea floor, corresponding to a lid thickness of ~1.6 km. Along this part of the southern EPR the AMC event is typically 450-500 ms below the sea floor and in some areas (e.g. SEPR-45 and 70) it is as shallow as 420 ms. This corresponds to a depth of ~1 km below the sea floor to the top of the axial magma chamber. J. Orcutt reports that preliminary shipboard analysis of OBS data from the 17°20'S area suggests a thinner layer 2 at the rise axis than on the northern EPR which is consistent with this interpretation of the CDP reflection data.

6.0 Comments and Recommendations

On EW 91-02 we were able to accomplish all of the major elements of a very ambitious field program laid out for the SEPR experiment. This success is in large part due to the tireless efforts of many individuals in the scientific party and among the ship's crew including Joe Stennett who kept the DSS-240 system up and running while dealing with dozens of other "problems" around the lab, Johnny D and his crew for keeping 20 airguns firing almost continuously for 24 days, Steve Pica and the ship's engineers for the superb job they did with the LMF compressors, the close co-operation of Captain O'Loughlin and the bridge officers, and of course the hard work and dedication of the watchstanders who loaded and unloaded over 1000 magnetic tapes during the course of this experiment.

The one significant exception to the very cooperative atmosphere on both ships was the Master of the *Washington*, Captain Desjardens. He refused to meet prior to the 2-ship work to discuss ESP procedures and insisted on port-to-port crossings during all of the ESPs, even when the *Washington* approached the midpoint well on *Ewing's* starboard bow. This necessitated a radical course change, usually carried out at about 2 nm ship-to-ship range, to bring *Washington* across our bow for a port-to-port crossing. Captain Desjardens also insisted on 0.5 nm minimum CPA, except for a few rise axis ESPs when, only with special pleading, he agreed to a 0.25-0.3 nm CPA. These maneuvers will severely complicate the processing and interpretation of the short-range ESP information and were totally avoidable.

The other major disappointment on this leg was the performance of Hydrosweep. Except for when it was operating right at the rise axis, Hydrosweep data quality was very poor with significant beam drop outs and large numbers of isolated depth artifacts or "divots" that result in circular, closed-contour bathymetric lows. On the cross-profile display one often sees two spurious troughs centered on beams 10-21 and 38-49 flanking the apparently valid depths on beams 22-37 (innermost beams) producing a "double-tunnel" effect in the contoured bathymetry. S/N on the outer two-thirds of the swath is often <10. These problems are generally more pronounced on the port beams. The system is also very sensitive to heat, and lab temperatures above about 75°F cause a serious degradation in system performance. During transits <30-50% of the Hydrosweep data is useable, and even the better quality data collected near the rise axis will require extensive and time-consuming editing to remove noise artifacts. There is no question that Hydrosweep on the *Ewing* suffers from a number of serious problems. These problems may be at least partly related to high levels of acoustic noise, although its temperature sensitivity and the systematically low S/N on beams 10-21 and 38-49 suggest there may be other problems as well. Isolating and correcting these problems should be given a very high priority by L-DGO before any other Hydrosweep programs are carried out.

We were generally very pleased with the operation of the MCS system on EW 91-02. As on the previous leg the 20-gun array proved to be a well-designed and very reliable system. Once it was properly balanced the streamer also performed very well. The part of the system that gave us the most difficulty was the DSS-240 control unit. Throughout the leg it was prone to frequent crashes and although only a few shots were missed, the crashes were a constant nuisance and sometimes occurred at very inopertune moments (e.g. right when we were crossing the ridge crest). This was the first *Ewing* leg to use a 4-km long streamer. The extra 1000 m of offset and additional channels are a valuable enhancement to the existing system. The additional ship handling problems of towing a 4 km streamer were not serious, although towing tension must be monitored much more closely. A 4 km streamer may also require a stronger streamer sheath to withstand the added weight on the inner wraps when the entire 4 km is on the reel. However, it appears possible to routinely tow a 4 km streamer from the *Ewing*, at least for surveys in areas with reasonably good weather conditions. The experiment of putting a GPS receiver in the tailbuoy was not successful on this leg, but with a watertight container for the receiver and power from the streamer such a system is potentially feasible.

The *Ewing* is a comfortable and very capable scientific research vessel. Below we offer some specific recommendations that we believe would further improve the capabilities of this vessel:

- An onboard, offline seismic processing system should be a standard feature aboard *Ewing*. On this leg we attempted to cobble together such a system by shipping out a Sun workstation from Lamont, a disk from URI and borrowing a tape drive and printer from UT. As frequently happens when this is done, we were unprepared for a major system crash which made the Sun disk effectively inoperative. Fortunately we were able to juryrig a system by time sharing on a Masscomp also used for other purposes. Onboard processing proved invaluable both as a quality control check on data being recorded and for preliminary data analysis. The acquisition of a permanent onboard processing capability should be a high priority. It should consist of a dedicated workstation, a 6250 bpi tape drive, two large capacity disk drives (1 Gb) and a printer.

- The computer situation onboard *Ewing* is presently a mess; there are at least four different kinds of computers running three different operating systems; there are no 6250 bpi tape drives except those used with the DSS-240, no SCSI interfaces on the Masscomps, Fortran manuals exist for the Silicon Graphics workstations, but the machines do not have a Fortran compiler etc. etc. The two most common computers used by scientists at L-DGO and other oceanographic labs (Suns and Macs) are not routinely available on the ship (only if an individual PI lugs them to some distant port). Some serious thought should go into developing a more *unified, integrated* computing system for the ship. We recommend this system include 2 or 3 Sun Sparcstations (replacing the Silicon Graphics machines immediately and the Masscomps/VAXes at some later date), 2 Mac SEs (for word processing and graphics), and 1 386 PC. All these computers should be linked via the shipboard Ethernet.

- The Magnavox T-sets, which are now the primarily navigation sensors for *Ewing*, are no longer state-of-the-art. The Magnavox MX 4200 receivers brought on EW 91-02 for differential GPS generally tracked more satellites and gave more hours of reliable navigation each day than did either T-set. These old GPS receivers should be replaced.

- Some improvements should be made to the MCS deck operations. On-deck lighting should be improved for night operations. Presently the two large arc lights that provide most of the illumination for the fantail make it difficult for the winch operator to see the streamer wrapping on the reel. Lighting could be better distributed around the fantail with more direct illumination of the streamer reel. A streamer roller should be installed beneath the A-frame at the edge of the fantail.

Scraping of the streamer along the deck may have contributed to some of the leakage problems we encountered. Finally, consideration should be given to the safety hazard represented by streamer oil. During streamer deployment and recovery operations on this leg we had large quantities of kerosene under the streamer reel draining across the starboard slop deck, mounds of oil soaked rags used for padding, and streamer handlers with kerosene-soaked clothes. Not only was there the possibility of injury from a fall on a slippery, oil-soaked deck but there is also a potential fire hazard. Steps that could be taken include sealing the streamer base and draining leaking kerosene to a holding tank below decks, and routinely having a fire extinguisher on the fantail.

- A User's Manual is needed for Hydrosweep giving an explanation of the console settings and suggested parameters. Right now all that is available are a few yellow sheets of note paper taped to the wall behind the console. The MCS watches at the beginning of a leg would also be less chaotic if the procedures for starting, ending and restarting MCS recording were written up and available.

Table 1

EW 91-02 Scientific Party

R. Detrick (GSO/URI) and J. Mutter (L-DGO) - co-chief scientists
Joe Stennett (L-DGO) - science officer
Jim Dolan (GSO/URI) - Hydrosweep technician
Paul Henkart (SIO) - seismic processor
Adriana Sepulveda (L-DGO) - scientist/watchstander
Stacey Tighe (GSO/URI) - scientist/watchstander
Emilio Vera (L-DGO) - scientist/watchstander
Jay Ardai (L-DGO) - airgun/compressor technician
Budhy Budhypramono (L-DGO) - computer systems manager
John Dibernardo (L-DGO) - airgun technician
Ruben Smith (L-DGO) - airgun technician
David Voegele (TAMU) - electronics technician

Jim O'Loughlin - Captain; Ian Smith - Chief Mate; Steve Pica - Chief Engineer

Table 2

OBS Deployment Sites

17°20'S Area	
Opus	17° 20.834'S, 113° 07.570'W
Phred	17° 17.303'S, 113° 10.127'W
Judy	17° 22.634'S, 113° 11.471'W
Sharyn	17° 19.279'S, 113° 14.153'W
Karen	17° 18.723'S, 113° 16.301'W
Janice	17° 21.294'S, 113° 05.295'W
15°55'S OSC	
	15° 50.45'S, 112° 57.70'W
	15° 54.30'S, 113° 01.65'W
	15° 54.85'S, 112° 57.30'W
	15° 55.40'S, 112° 52.90'W
	15° 57.50'S, 113° 02.00'W
	15° 59.25'S, 112° 56.80'W
14°15'S Area	
Opus	14° 14.9'S, 112° 33.0'W
Phred	14° 12.05'S, 112° 28.7'W
Judy	14° 07.6'S, 112° 31.1'W
Sharyn	14° 18.9'S, 112° 30.5'W
Karen	14° 19.3'S, 112° 37.5'W
Janice	14° 10.7'S, 112° 35.25'W

Figure Captions

Fig. 1 Tectonic map of the EPR south of the Garrett fracture and north of the Easter Microplate (from Sinton et al., 1991)

Fig. 2 Depth of the EPR rise axis between 23°S and 13°S. The letters A-to-O refer to the magmatic segmentation of the rise axis inferred geochemically by Sinton et al. (1991).

Fig. 3 Location of seismic data collected on EW 91-02 (see Figs. 5-9 for line coverage in the three detailed survey areas).

Fig. 4 Representative shot gather for one shot from *Ewing's* 8183 cu. in. airgun array received on the 4-km, 160 channel streamer used on EW 91-02.

Fig. 5 Simplified line drawing showing location of CDP reflection profiles in the 17°20'S area.

Fig. 6 Simplified line drawing showing location of ESP profiles in the 17°20'S area.

Fig. 7 Simplified line drawing showing location of CDP reflection profiles at the 15°55'S OSC.

Fig. 8 Simplified line drawing showing location of CDP reflection profiles in the 14°15'S area.

Fig. 9 Simplified line drawing showing location of ESP profiles in the 14°15'S area.

Fig. 10 Single channel monitor record from SEPR-69 which crosses the EPR near 14°15'S. The source was a 4193 cu. in. airgun array. Note the narrow, relatively flat AMC event about 450 ms beneath the rise axis.

Fig. 11 Single channel monitor record from SEPR-45 which was shot along the crest of the EPR. The source was a 8385 cu. in. airgun array. Note the strong sub-horizontal AMC event just below 4 s two way travel time and the variation in amplitude of this event from south to north along the rise axis.

Fig. 12 A low-fold stacked section of SEPR 28 which crosses the EPR near 17°22'S. A narrow AMC event is apparent about 500 ms below the sea floor, offset slightly to east of the center of the axial high.

Fig. 13 A low-fold stacked section of SEPR 70 which crosses the EPR near 14°15'S. An exceptionally strong, shallow (~420 ms), and wide (~1.7 km) AMC event is located beneath the rise axis on this profile.

Fig. 14 A low-fold stacked section of SEPR 45 which runs along the crest of the EPR near 14°15'S. The AMC event is located near 4 sec two way travel time and is quite continuous along the rise axis in the stacked data.

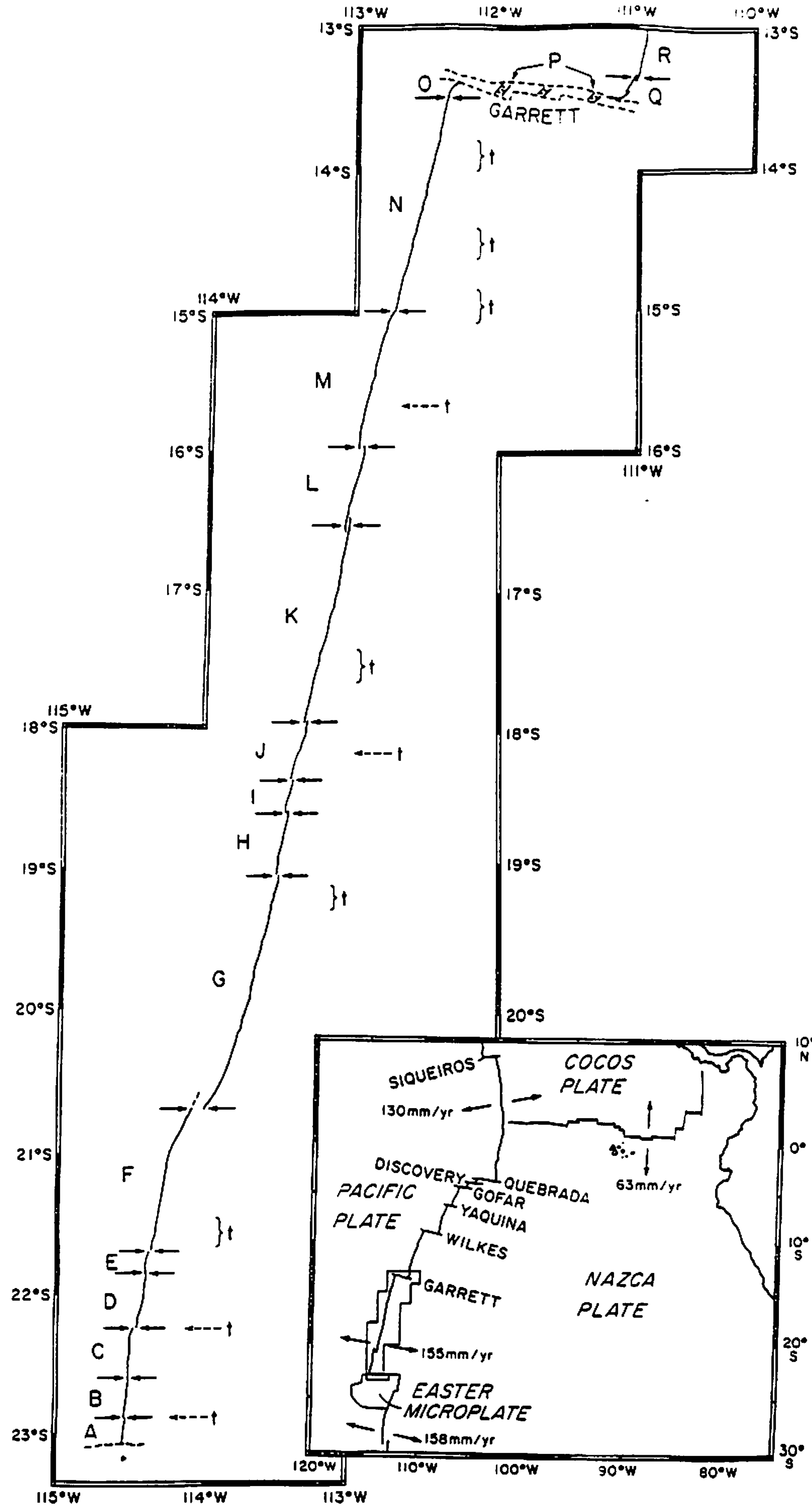

113°W
112°W
111°W
110°W
13°S
P
R
O
Q
GARRETT
14°S
N
114°W
15°S
M
16°S
111°W
L
17°S
K
115°W
18°S
J
I
H
19°S
G
20°S
F
21°S
E
22°S
D
C
B
A
23°S
115°W
114°W
113°W
SIQUEIROS
COCOS PLATE
130mm/yr
DISCOVERY
QUEBRADA
GOFAR
YAQUINA
WILKES
PACIFIC PLATE
63mm/yr
GARRETT
NAZCA PLATE
155mm/yr
EASTER MICROPLATE
158mm/yr
120°W
110°W
100°W
90°W
80°W
10° N
0°
10° S
20° S
30° S

Fig. 1

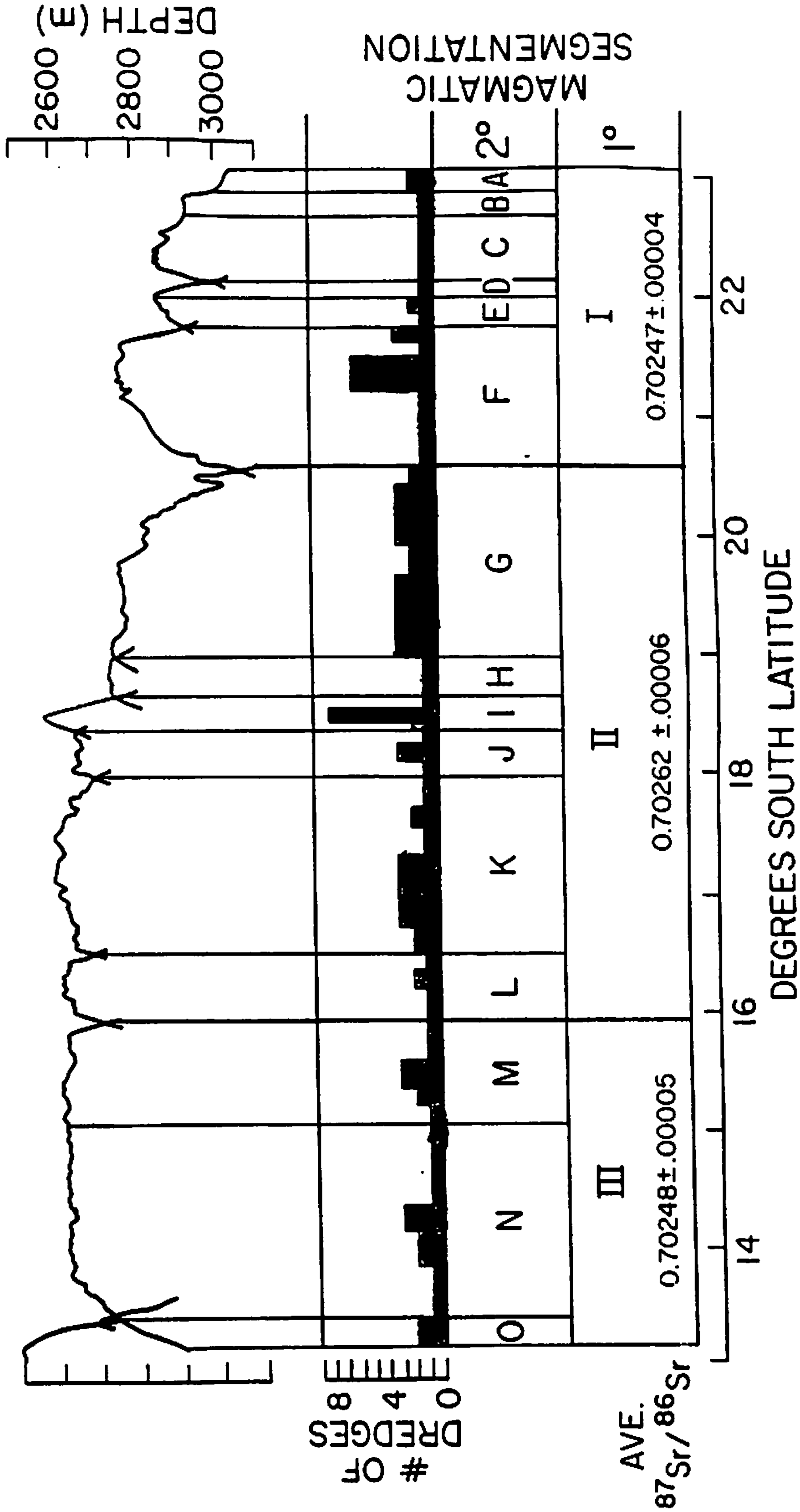

DEPTH (m)
2600
2800
3000
MAGMATIC SEGMENTATION
2°
1°
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
I
II
III
0.70247±.00004
0.70262 ±.00006
0.70248±.00005
OF DREDGES
8
4
0
AVE. $^{87}Sr/^{86}Sr$
14
16
18
20
22
DEGREES SOUTH LATITUDE

Fig. 2

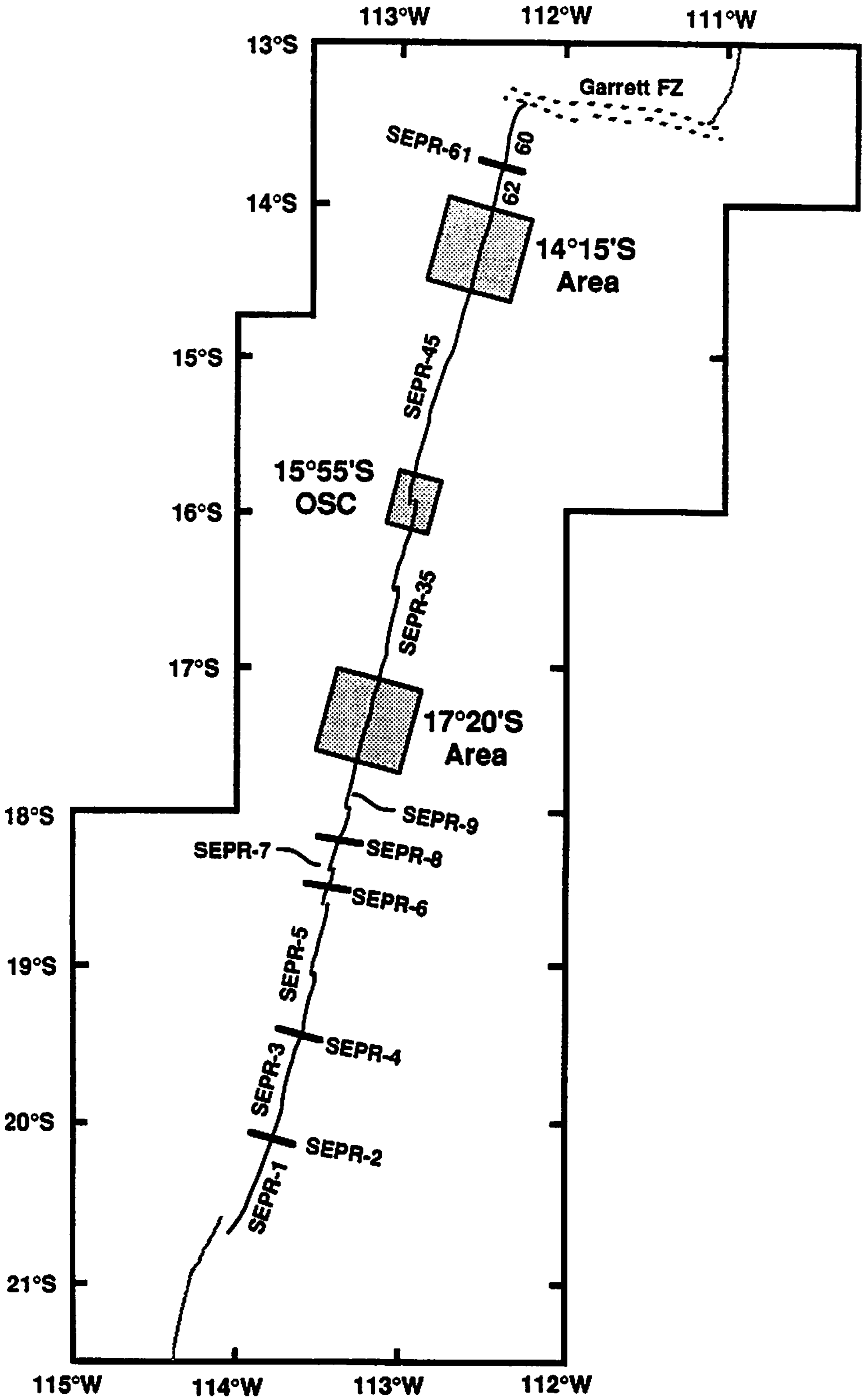

113°W
112°W
111°W
13°S
Garrett FZ
SEPR-61
60
62
14°S
14°15'S
Area
15°S
SEPR-45
15°55'S
OSC
16°S
SEPR-35
17°S
17°20'S
Area
18°S
SEPR-9
SEPR-8
SEPR-7
SEPR-6
SEPR-5
19°S
SEPR-4
SEPR-3
20°S
SEPR-2
SEPR-1
21°S
115°W
114°W
113°W
112°W

Fig. 3

Shot Gather SEPR-19 JD 102 18:38:40 Z
8183 cu. in. airgun array
4-km streamer, 25-m group spacing

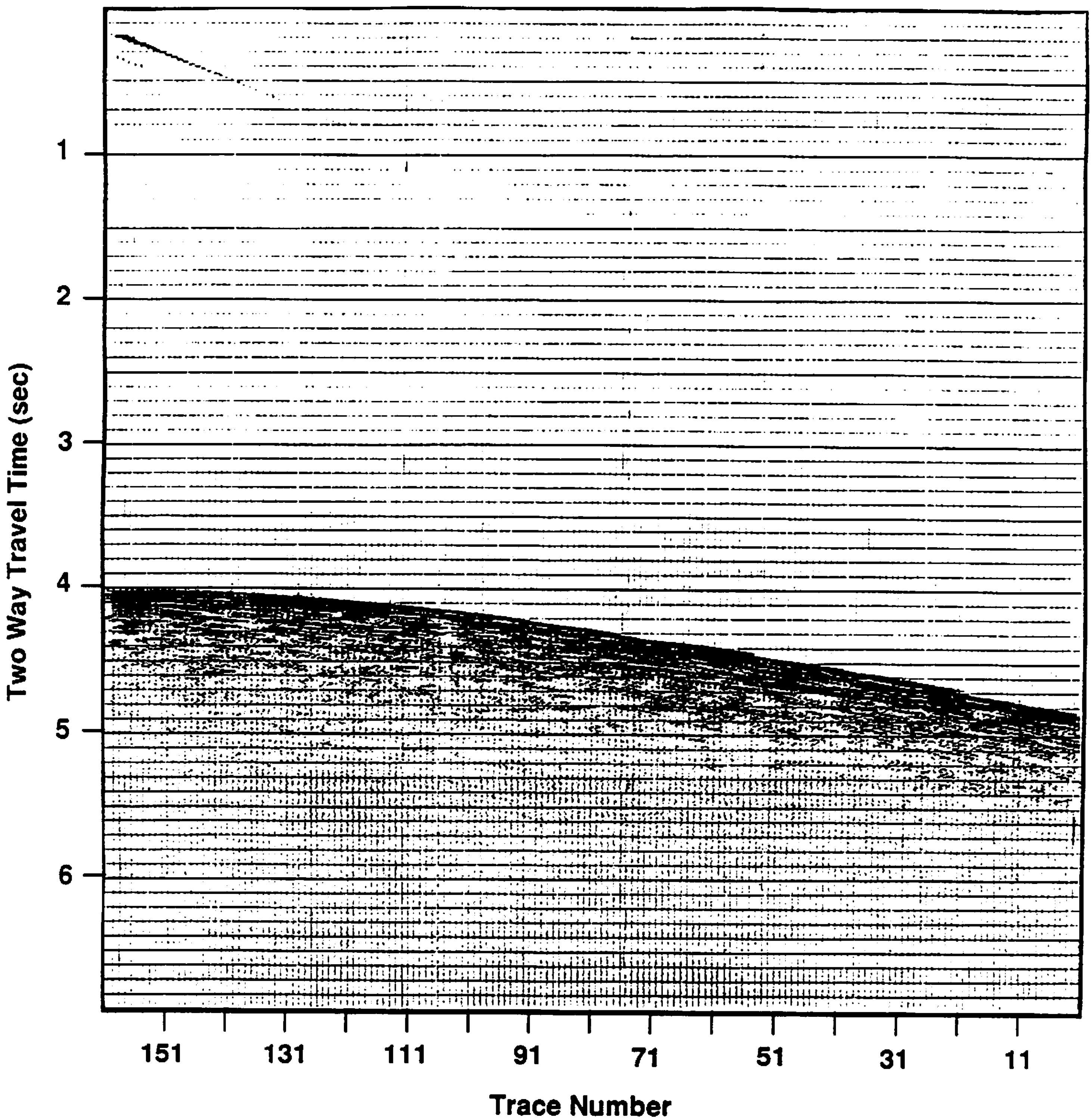
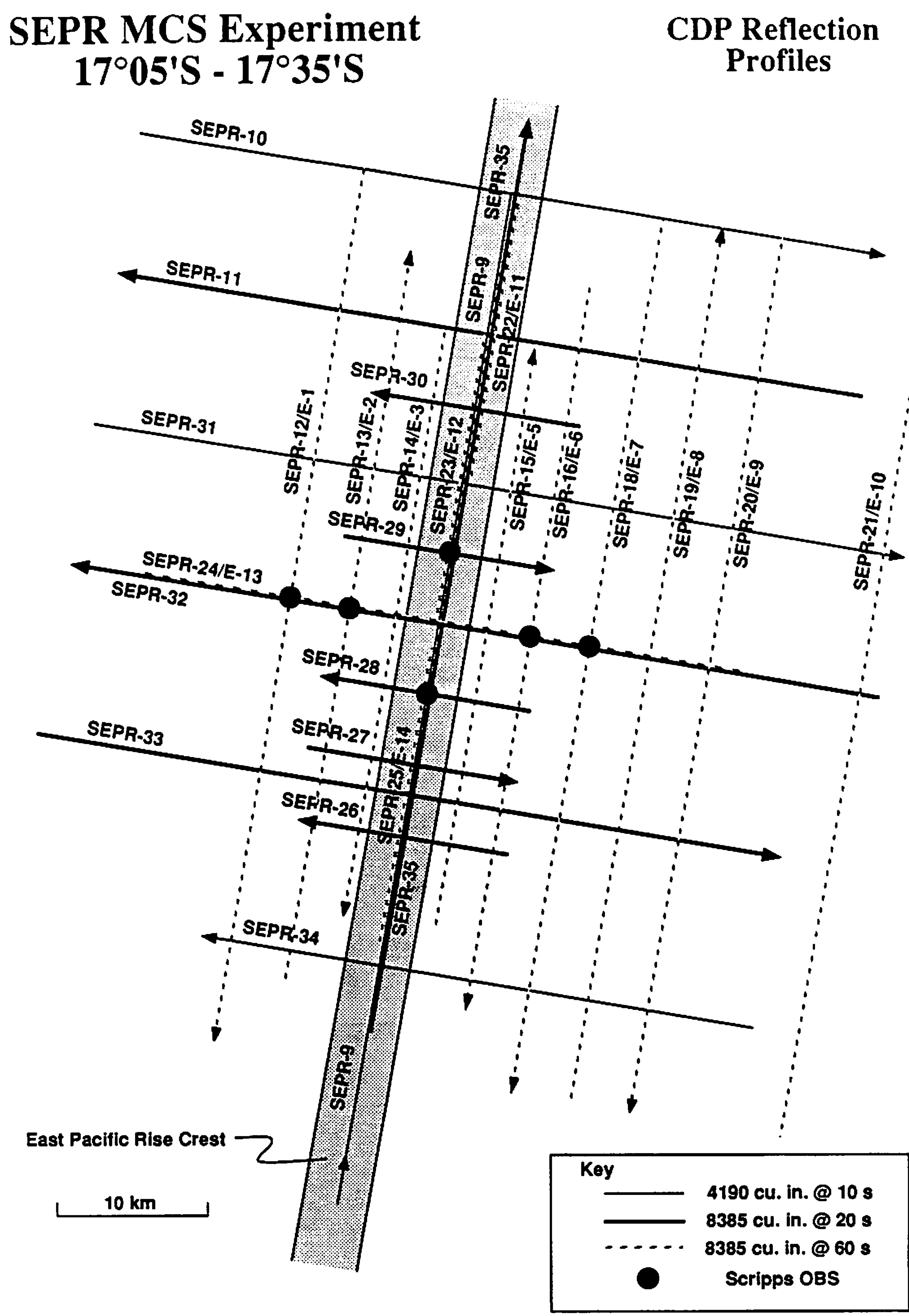
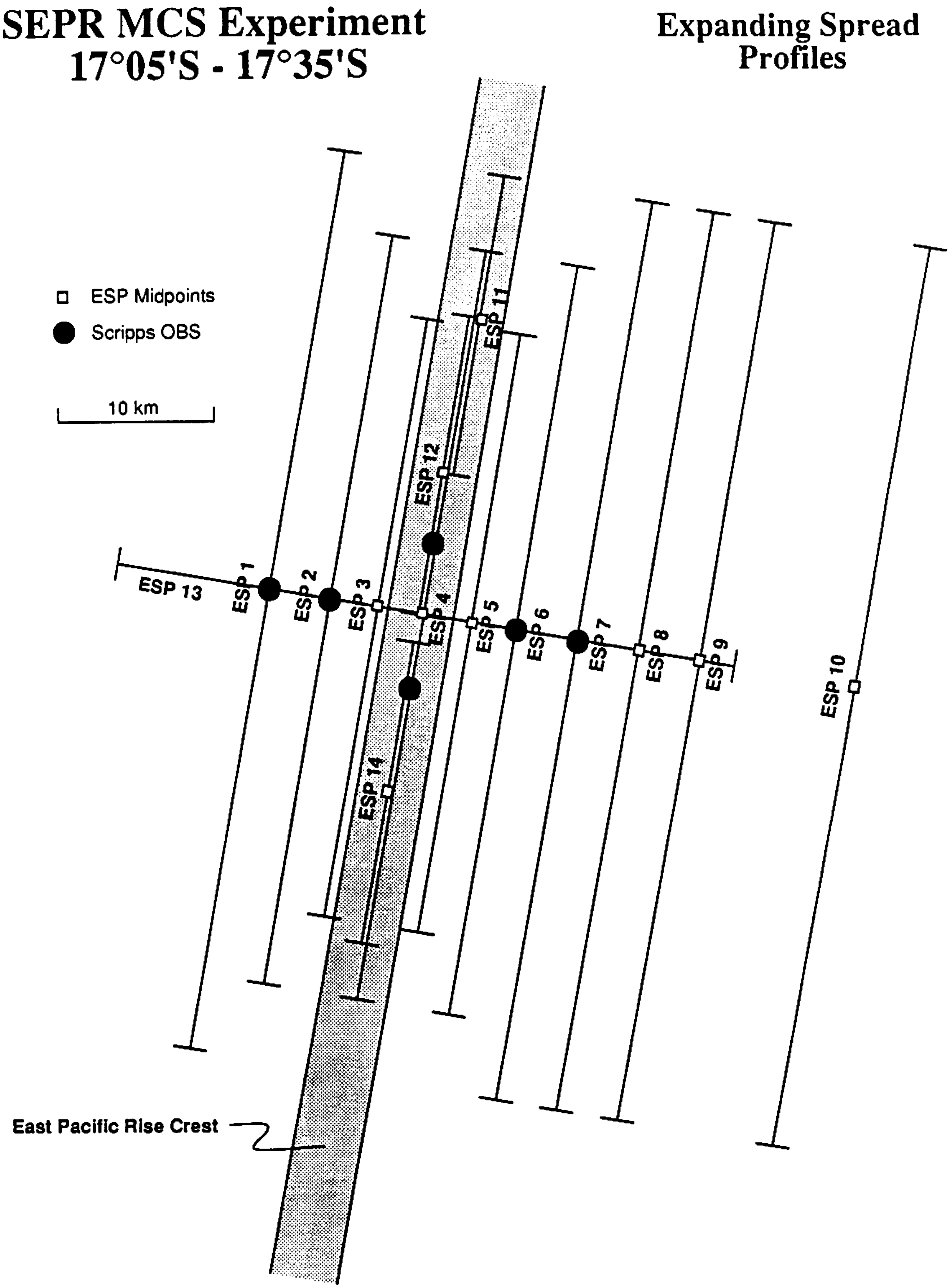


Fig. 4



SEPR MCS Experiment
17°05'S - 17°35'S
CDP Reflection Profiles
SEPR-10
SEPR-11
SEPR-30
SEPR-31
SEPR-29
SEPR-24/E-13
SEPR-32
SEPR-28
SEPR-27
SEPR-33
SEPR-26
SEPR-34
SEPR-35
SEPR-9
SEPR-22/E-11
SEPR-12/E-1
SEPR-13/E-2
SEPR-14/E-3
SEPR-23/E-12
SEPR-15/E-5
SEPR-16/E-6
SEPR-18/E-7
SEPR-19/E-8
SEPR-20/E-9
SEPR-21/E-10
SEPR-25/E-14
East Pacific Rise Crest
10 km
Key
4190 cu. in. @ 10 s
8385 cu. in. @ 20 s
8385 cu. in. @ 60 s
Scripps OBS

Fig. 5



SEPR MCS Experiment
17°05'S - 17°35'S
Expanding Spread
Profiles
ESP Midpoints
Scripps OBS
10 km
ESP 1
ESP 2
ESP 3
ESP 4
ESP 5
ESP 6
ESP 7
ESP 8
ESP 9
ESP 10
ESP 11
ESP 12
ESP 13
ESP 14
East Pacific Rise Crest

Fig. 6

SEPR MCS Experiment
15°55'S OSC

CDP Reflection Profiles

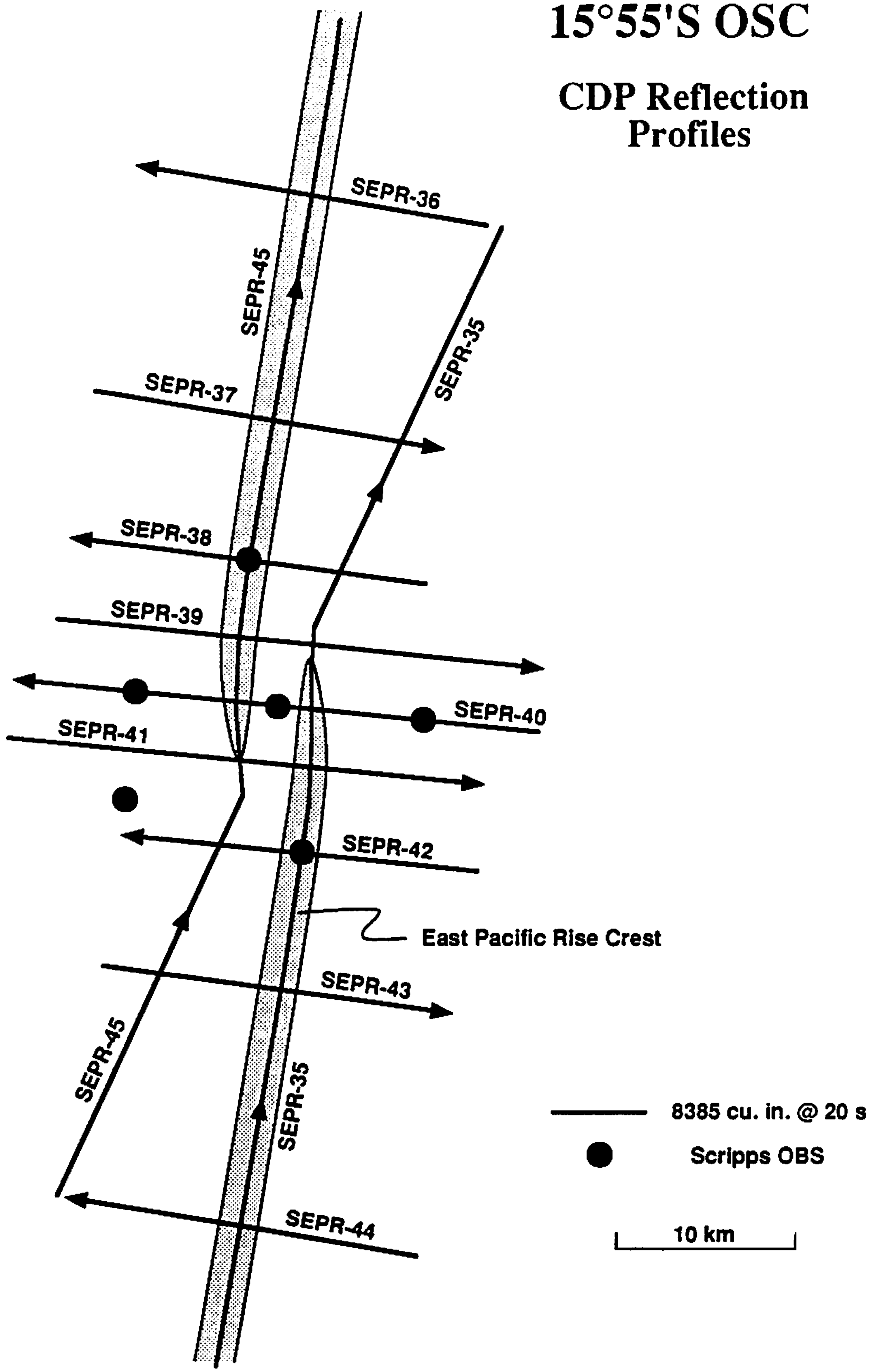


Fig. 7

SEPR MCS Experiment
14°00'S - 14°30'S

CDP Reflection Profiles

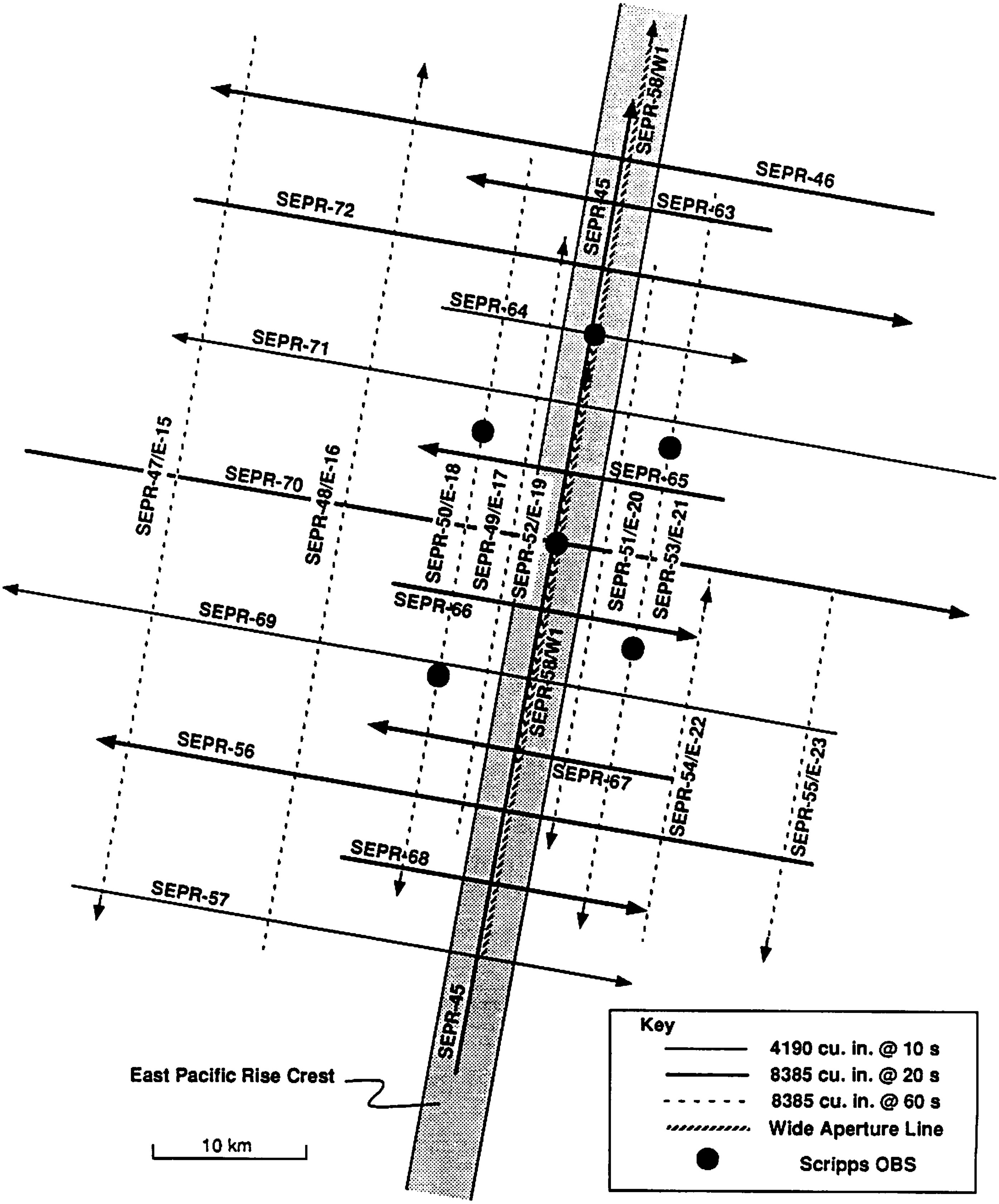


Fig. 8

SEPR MCS Experiment
14°00'S - 14°30'S

Expanding Spread Profiles

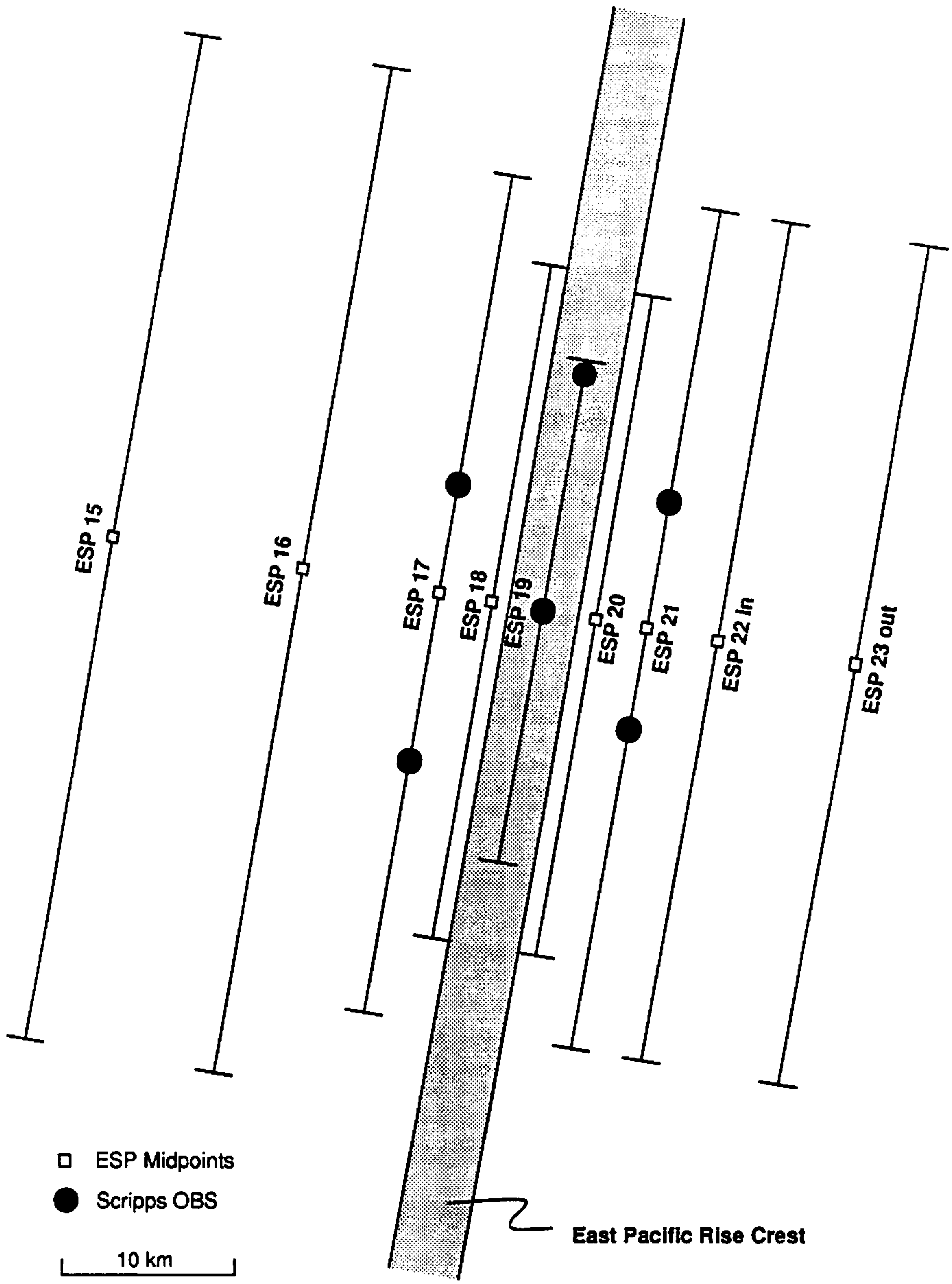


Fig. 9

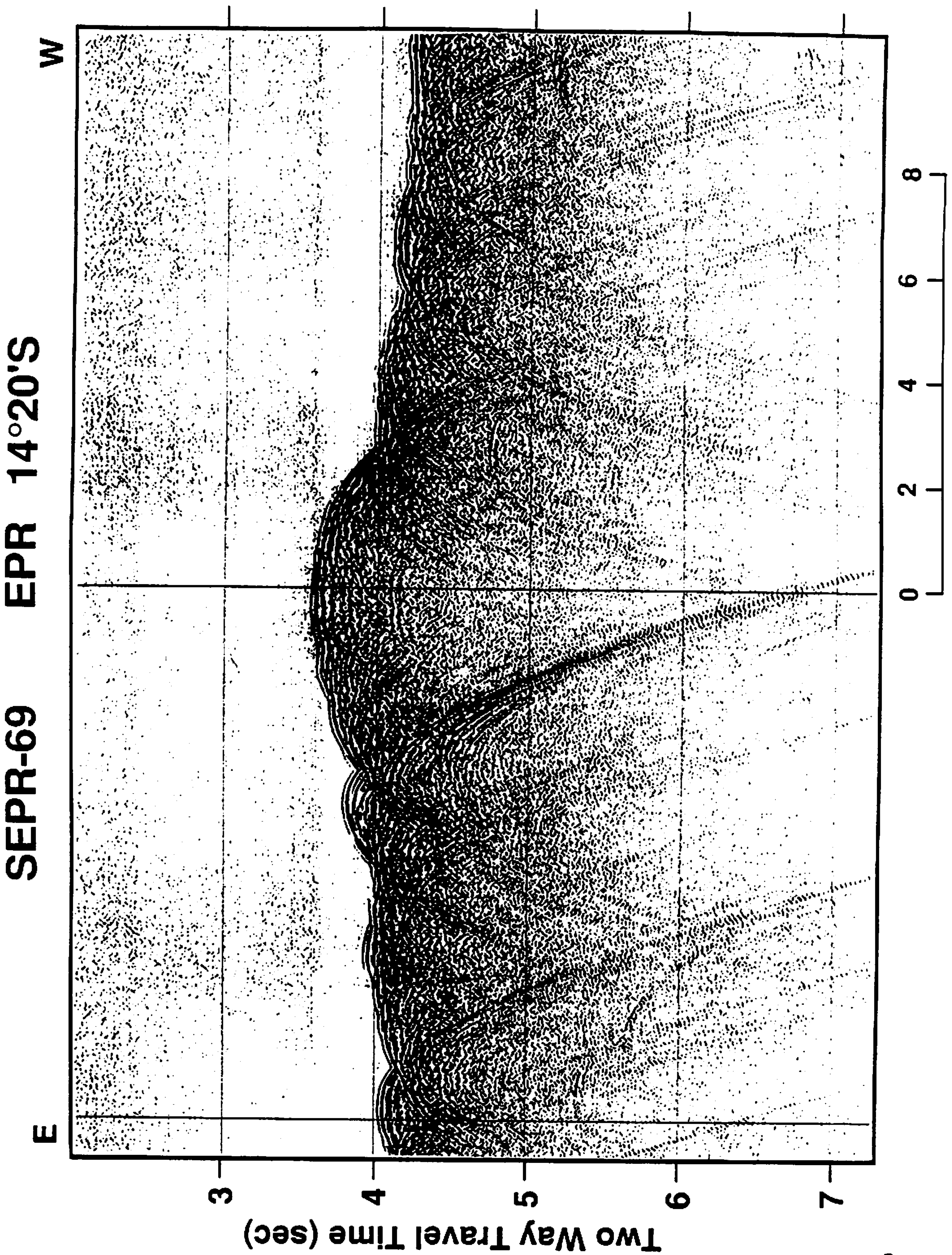


Fig. 10

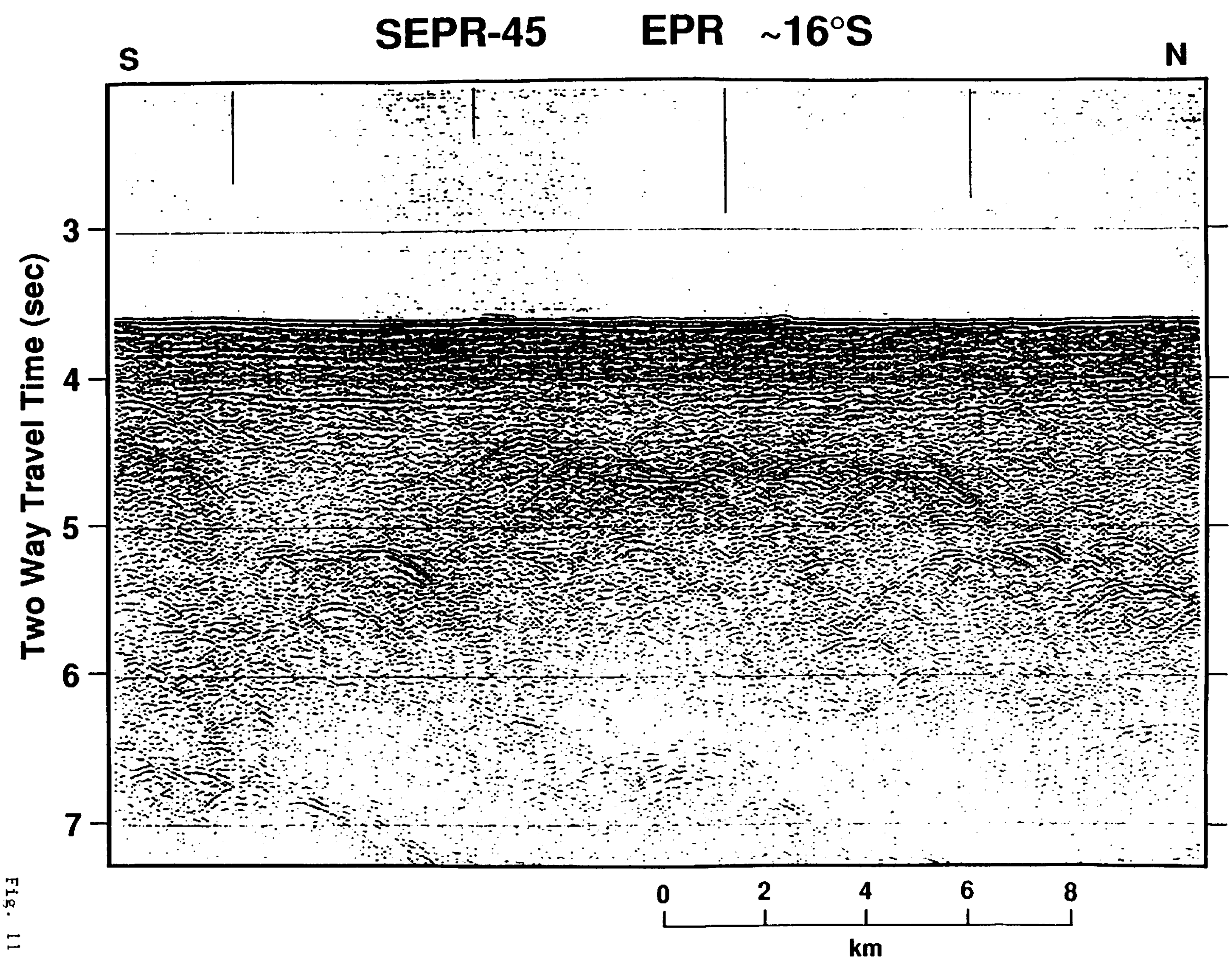


Fig. 11

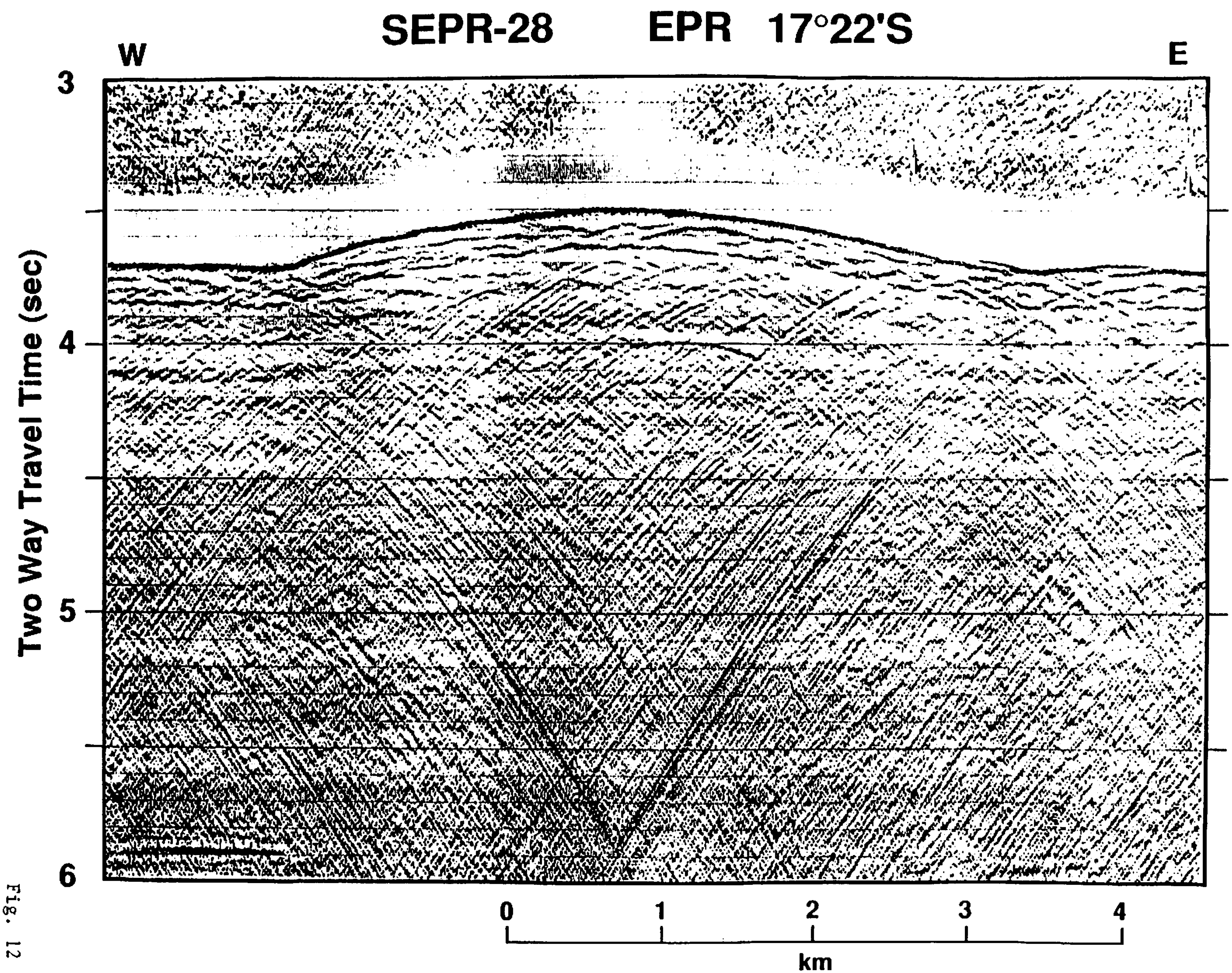


Fig. 12

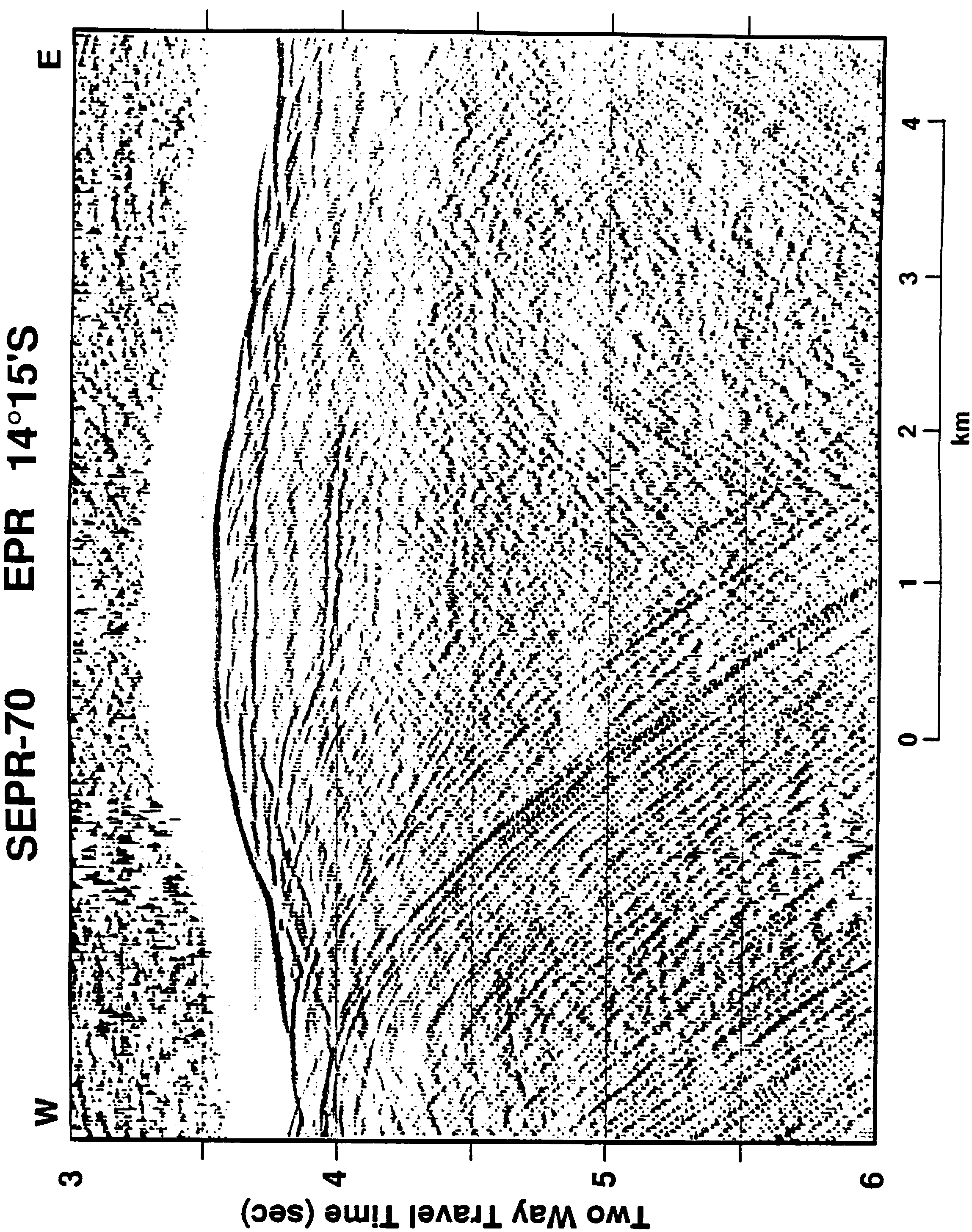


Fig. 13

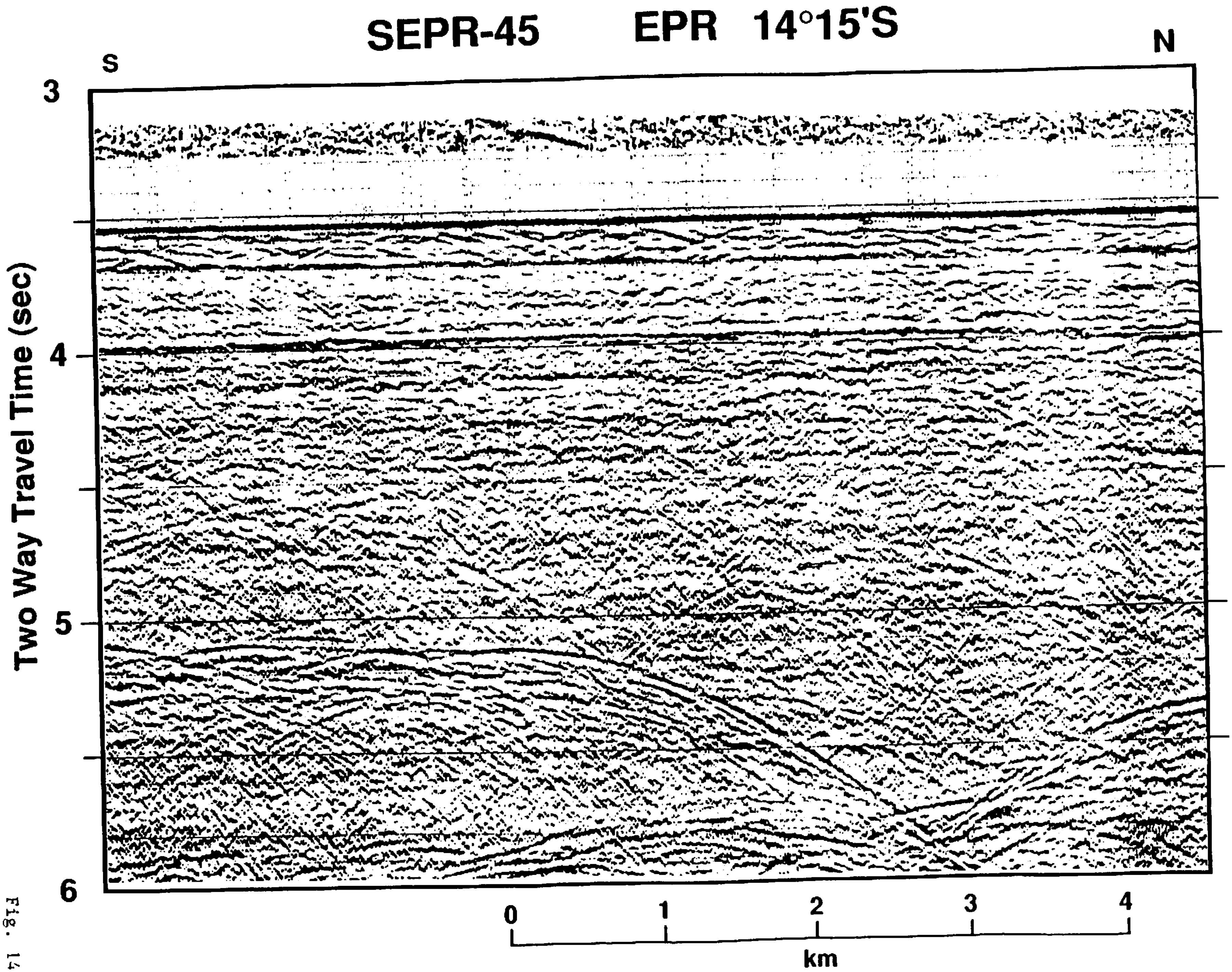


Fig. 14

Appendix 1 EW 91-02 MCS Line Log

Line #	J.D.	Date	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Source Airguns (cu. in.)	Source S.I. (s)	Receiver Traces	Receiver Groups (m)	Receiver Records (s)
SEPR-1	95	5-Apr-91	10:07	20°37.9'S	113°56.0'W	1	1	1	4193	10	160	25	8.8
	95	5-Apr-91	16:47	20°08.8'S	113°43.1'W	18	2404	2344					
SEPR-2	95	5-Apr-91	19:54	20°11.3'S	113°38.5'W	19	?	1	4193	10	160	25	8.8
	95	5-Apr-91	22:20	20°08.1'S	113°49.0'W	25	4396	846					
SEPR-3	96	6-Apr-91	01:37	20°08.1'S	113°43.2'W	26	?	1	4193	10	160	25	8.8
	96	6-Apr-91	10:44	19°25.4'S	113°32.6'W	50	8848	3272					
SEPR-4	96	6-Apr-91	13:52	19°27.7'S	113°28.6'W	51	9989	1	4193	10	160	25	8.8
	96	6-Apr-91	16:13	19°24.8'S	113°39.7'W	57	10838	839					
SEPR-5	96	6-Apr-91	19:05	19°27.2'S	113°33.2'W	58	11865	840	4193	10	160	25	8.8
	97	7-Apr-91	11:10	18°26.4'S	113°23.6'W	101	17655	6561					
SEPR-6	97	7-Apr-91	14:05	18°28.6'S	113°18.3'W	102	18705	898	4193	10	160	25	8.8
	97	7-Apr-91	16:25	18°26.3'S	113°30.2'W	108	19548	1741					
SEPR-7	97	7-Apr-91	19:14	18°27.6'S	113°23.7'W	109	20563	10	4193	10	160	25	8.8
	97	7-Apr-91	22:31	18°12.0'S	113°21.1'W	117	21740	1180					
SEPR-8	98	8-Apr-91	01:14	18°14.0'S	113°15.8'W	118	22726	1	4193	10	160	25	8.8
	98	8-Apr-91	03:42	18°11.8'S	113°28.0'W	124	23615	833					
SEPR-9	98	8-Apr-91	06:25	18°13.4'S	113°21.4'W	125	24593	242	4193	10	160	25	8.8
	98	8-Apr-91	21:29	17°01.7'S	113°06.3'W	164	30001	1688					
SEPR-10	99	9-Apr-91	14:50	16°53.6'S	113°34.2'W	165	36267	1	4193	10	160	25	8.8
	100	10-Apr-91	00:10	17°07.8'S	112°52.0'W	190	39612	3333					
SEPR-11	100	10-Apr-91	04:01	17°13.3'S	112°51.8'W	191	40970	5	8385	20	160	25	18.75
	100	10-Apr-91	10:03	17°05.8'S	113°23.1'W	204	42052	1082					
SEPR-12	100	10-Apr-91	13:32	17°04.1'S	113°12.8'W	205	42674	1	8385	60	160	25	18.75
(ESP-1)	100	10-Apr-91	20:03	17°35.4'S	113°20.6'W	221	43848	1169	2850	60	160	25	2x18.75
SEPR-13	100	10-Apr-91	21:42	17°32.3'S	113°17.6'W	222	44144	1	8385	60	160	25	18.75
(ESP-2)	101	11-Apr-91	03:21	17°04.6'S	113°10.3'W	242	45156	1011	2850	60	160	25	2x18.75
SEPR-14	101	11-Apr-91	04:55	17°10.8'S	113°10.1'W	243	45412	1	8385	60	160	25	18.75
(ESP-3)	101	11-Apr-91	09:26	17°31.4'S	113°15.5'W	254	0	813	2850	60	160	25	2x18.75
SEPR-15	101	11-Apr-91	13:11	17°30.0'S	113°11.7'W	255	46901	1	8385	60	160	25	18.75

Appendix 1 EW 91-02 MCS Line Log

									Source		Receiver		
Line #	J.D.	Date	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Airguns (cu. in.)	S.I. (s)	Traces	Groups (m)	Records (s)
(ESP-5)	101	11-Apr-91	17:37	17°08.6'S	113°06.3'W	266	47691	788	2850	60	160	25	2x18.75
SEPR-16	101	11-Apr-91	19:02	17°07.7'S	113°04.6'W	267	47953	1	8385	60	160	25	18.75
(ESP-6)	102	12-Apr-91	00:32	17°34.8'S	113°11.0'W	281	48940	986	2390	60	160	25	2x18.75
SEPR-17	102	12-Apr-91	01:50	17°32.3'S	113°14.5'W	282	49179	13	8385	60	160	25	18.75
(ESP-4)	102	12-Apr-91	07:13	17°05.5'S	113°07.3'W	296	50144	978	2390	60	160	25	2x18.75
SEPR-18	102	12-Apr-91	09:32	17°06.6'S	113°01.7'W	297	50563	1	8385	60	160	25	18.75
(ESP-7)	102	12-Apr-91	14:07	17°27.9'S	113°07.0'W	308	51389	803	2390	60	160	25	2x18.75
SEPR-19	102	12-Apr-91	18:38	17°36.6'S	113°07.1'W	309	52202	1	8385	60	160	25	18.75
(ESP-8)	103	13-Apr-91	01:05	17°36.6'S	112°58.6'W	325	53361	1160	2390	60	160	25	2x18.75
SEPR-20	103	13-Apr-91	02:03	17°07.6'S	112°57.1'W	326	53537	23	8385	60	160	25	18.75
(ESP-9)	103	13-Apr-91	08:42	17°39.0'S	113°05.3'W	351	54735	1219	2390	60	160	25	2x18.75
SEPR-21	103	13-Apr-91	10:22	17°37.7'S	112°59.8'W	352	55035	1	8385	60	160	25	18.75
(ESP-10)	103	13-Apr-91	16:46	17°06.7'S	112°51.6'W	367	272	1105	2390	60	160	25	2x18.75
SEPR-22	103	13-Apr-91	21:25	17°05.6'S	113°07.1'W	369	1108	1	8385	60	160	25	18.75
(ESP-11)	103	13-Apr-91	23:36	17°16.0'S	113°09.8'W	374	1503	396	2390	60	160	25	2x18.75
SEPR-23	104	14-Apr-91	01:40	17°19.1'S	113°10.6'W	375	1875	1	8385	60	160	25	18.75
(ESP-12)	104	14-Apr-91	03:57	17°08.4'S	113°07.9'W	382	2278	389	2390	60	160	25	2x18.75
SEPR-24	104	14-Apr-91	07:52	17°19.0'S	113°15.8'W	383	687	1	8385	60	160	25	18.75
(ESP-13)	104	14-Apr-91	11:13	17°22.7'S	112°58.5'W	391	1292	606	2390	60	160	25	2x18.75
SEPR-25	104	14-Apr-91	14:49	17°22.4'S	113°11.3'W	392	1952	11	8385	60	160	25	18.75
(ESP-14)	104	14-Apr-91	17:06	17°32.8'S	113°13.9'W	397	2348	407	2390	60	160	25	2x18.75
SEPR-26	104	14-Apr-91	19:48	17°28.5'S	113°08.6'W	397A	22	1	8385	20	160	25	18.75
	104	14-Apr-91	21:39	17°26.2'S	113°18.7'W	401	355	334					
SEPR-27	104	14-Apr-91	22:41	17°24.1'S	113°17.2'W	402	542	1	8385	20	160	25	18.75
	105	15-Apr-91	00:55	17°26.5'S	113°07.2'W	407	180	399					
SEPR-28	105	15-Apr-91	02:20	17°23.5'S	113°07.7'W	408	436	1	8385	20	160	25	18.75
	105	15-Apr-91	04:06	17°21.6'S	113°16.3'W	413	753	317					
SEPR-29	105	15-Apr-91	06:05	17°16.4'S	113°14.1'W	415	1111	2	8385	20	160	25	18.75
	105	15-Apr-91	07:45	17°18.3'S	113°05.8'W	419	1410	301					

									Source		Receiver		
Line #	*J.D.*	*Date*	*Time (Z)*	*Latitude (Start/End)*	*Longitude (Start/End)*	*Tape #*	*Shot #*	*File #*	*Airguns (cu. in.)*	*S.I. (s)*	*Traces*	*Groups (m)*	*Records (s)*
SEPR-30	105	15-Apr-91	09:50	17°13.0'S	113°04.5'W	420	1785	1	8385	20	160	25	18.75
	105	15-Apr-91	11:41	17°10.9'S	113°13.7'W	424	2120	336					
SEPR-31	105	15-Apr-91	15:11	17°11.6'S	113°23.1'W	425	2750	3	4193	10	160	25	8.8
	105	15-Apr-91	21:28	17°18.9'S	112°52.5'W	448	4887	1951					
SEPR-32	105	15-Apr-91	23:32	17°23.6'S	112°55.6'W	449	5284	1	8385	20	160	25	18.75
	106	16-Apr-91	05:43	17°23.6'S	112°55.6'W	462	6395	1100					
SEPR-33	106	16-Apr-91	08:01	17°23.4'S	113°26.1'W	463	6810	1	8385	20	160	25	18.75
	106	16-Apr-91	14:30	17°29.8'S	112°58.0'W	477	7976	1159					
SEPR-34	106	16-Apr-91	16:47	17°36.1'S	113°00.4'W	479	8721	16	4193	10	160	25	8.8
	106	16-Apr-91	20:51	17°31.0'S	113°21.3'W	489	10169	1441					
SEPR-35	106	16-Apr-91	23:59	17°32.7'S	113°14.2'W	490	10954	1	8385	20	160	25	18.75
	107	17-Apr-91	23:59	15°43.4'S	112°48.3'W	543	15216	4243					
SEPR-36	108	18-Apr-91	00:49	15°40.9'S	112°51.7'W	544	15425	1	8385	20	160	25	18.75
	108	18-Apr-91	02:52	15°38.7'S	113°01.6'W	548	15794	370					
SEPR-37	108	18-Apr-91	05:03	15°45.3'S	113°02.3'W	549	~16181	1	8385	20	160	25	18.75
	108	18-Apr-91	07:27	15°47.7'S	112°50.1'W	554	16618	435					
SEPR-38	108	18-Apr-91	09:06	15°51.0'S	112°53.6'W	555	16916	1	8385	20	160	25	18.75
	108	18-Apr-91	11:14	15°49.1'S	113°04.5'W	559	17301	386					
SEPR-39	108	18-Apr-91	12:49	15°52.2'S	113°02.2'W	560	17585	1	8385	20	160	25	18.75
	108	18-Apr-91	15:45	15°54.1'S	112°48.3'W	566	18112	476					
SEPR-40	108	18-Apr-91	16:47	15°56.0'S	112°48.9'W	567	18301	1	8385	20	160	25	18.75
	108	18-Apr-91	20:13	15°53.5'S	113°07.1'W	574	18919	619					
SEPR-41	108	18-Apr-91	21:27	15°55.8'S	113°04.9'W	575	19139	1	8385	20	160	25	18.75
	109	19-Apr-91	00:27	15°57.8'S	112°50.2'W	581	19681	543					
SEPR-42	109	19-Apr-91	02:02	15°59.9'S	112°52.8'W	582	19964	1	8385	20	160	25	18.75
	109	19-Apr-91	04:09	15°58.3'S	113°03.4'W	586	20347	384					
SEPR-43	109	19-Apr-91	05:48	16°02.5'S	113°02.5'W	587	20642	1	8385	20	160	25	18.75
	109	19-Apr-91	08:16	16°04.1'S	112°50.2'W	592	21086	438					
SEPR-44	109	19-Apr-91	10:20	16°10.6'S	112°54.2'W	593	21458	1	8385	20	160	25	18.75

Appendix 1 EW 91-02 MCS Line Log

Line #	J.D.	Date	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Source Airguns (cu. in.)	Source S.I. (s)	Receiver Traces	Receiver Groups (m)	Receiver Records (s)
	109	19-Apr-91	12:28	16°08.7'S	113°05.0'W	597	21841	381					
SEPR-45	109	19-Apr-91	13:15	16°05.4'S	113°04.2'W	599	21983	1	8385	20	160	25	18.75
	110	20-Apr-91	16:34	13°55.5'S	112°28.8'W	660	26899	4898					
SEPR-46	110	20-Apr-91	19:58	14°03.0'S	112°18.5'W	661	27574	1	4193	10	160	25	8.8
	111	21-Apr-90	01:02	13°56.9'S	112°43.7'W	674	29395	1816					
SEPR-47	111	21-Apr-91	03:13	13°57.0'S	112°42.6'W	675	29934	1	8385	60	160	25	18.75
(ESP 15)	111	21-Apr-91	09:39	14°28.2'S	112°50.8'W	693	31095	1159	2850	60	160	25	2x18.75
SEPR-48	111	21-Apr-91	12:02	14°27.7'S	112°44.2'W	694	31522	1	8385	60	160	25	18.75
(ESP 16)	111	21-Apr-91	19:17	13°56.1'S	112°35.9'W	712	32827	1302	2850	60	160	25	2x18.75
SEPR-49	111	21-Apr-91	21:31	14°01.9'S	112°33.0'W	713	33229	1	8385	60	160	25	18.75
(ESP 17)	112	22-Apr-91	03:24	14°28.4'S	112°40.0'W	733	34288	1060	2850	60	160	25	2x18.75
SEPR-50	112	22-Apr-91	04:55	14°24.9'S	112°38.2'W	734	34561	1	8385	60	160	25	18.75
(ESP 18)	112	22-Apr-91	09:45	14°03.4'S	112°31.6'W	747	35431	871	2850	60	160	25	2x18.75
SEPR-51	112	22-Apr-91	11:09	14°06.1'S	112°28.7'W	748	35685	1	8385	60	160	25	18.75
(ESP 20)	112	22-Apr-91	15:44	14°26.6'S	112°34.3'W	760	36509	822	2850	60	160	25	2x18.75
SEPR-52	112	22-Apr-91	17:24	14°21.5'S	112°34.5'W	761	36810	1	8385	60	160	25	18.75
(ESP 19)	112	22-Apr-91	20:36	14°06.7'S	112°30.3'W	769	37384	575	2850	60	160	25	2x18.75
SEPR-53	112	22-Apr-91	23:06	14°04.3'S	112°26.6'W	770	37836	1	8385	60	160	25	18.75
(ESP 21)	113	23-Apr-91	04:42	14°30.1'S	112°33.0'W	784	38840	1002	2850	60	160	25	2x18.75
SEPR-54	113	23-Apr-91	06:05	14°28.8'S	112°29.5'W	785	39093	1	8385	60	160	25	18.75
(ESP 22)	113	23-Apr-91	09:22	14°12.0'S	112°26.4'W	793	39683	579	2850	60	160	25	2x18.75
SEPR-55	113	23-Apr-91	10:54	14°13.6'S	112°22.0'W	794	39959	1	8385	60	160	25	18.75
(ESP 23)	113	23-Apr-91	14:41	14°31.4'S	112°26.9'W	803	40637	665	2850	60	160	25	2x18.75
SEPR-56	113	23-Apr-91	16:50	14°27.3'S	112°23.8'W	804	41026	1	8385	20	160	25	18.75
	113	23-Apr-91	22:06	14°20.8'S	112°50.8'W	817	41976	948					
SEPR-57	114	24-Apr-91	00:10	14°26.1'S	112°50.1'W	818	42393	1	4193	10	160	25	8.8
	114	24-Apr-91	04:00	14°30.5'S	112°31.9'W	828	43769	1346					
SEPR-58	114	24-Apr-91	06:01	14°29.4'S	112°36.2'W	829	44344	1	2620	20	160	25	18.75
WARP-1	114	24-Apr-91	17:12	13°39.5'S	112°23.8'W	868	46358	2013	2850	20	160	25	18.75

Appendix 1 EW 91-02 MCS Line Log

									Source		Receiver		
Line #	J.D.	Date	Time (Z)	Latitude (Start/End)	Longitude (Start/End)	Tape #	Shot #	File #	Airguns (cu. in.)	S.I. (s)	Traces	Groups (m)	Records (s)
SEPR-59	114	24-Apr-91	19:10	13°31.5'S	112°22.0'W	868	46712	1	8385	20	160	25	18.75
	114	24-Apr-91	22:14	13°18.3'S	112°18.7'W	876	47263	540					
SEPR-60	114	24-Apr-91	23:37	13°21.3'S	112°18.6'W	877	47513	1	8385	20	160	25	18.75
	115	25-Apr-91	05:34	13°49.5'S	112°26.2'W	892	361	1059					
SEPR-61	115	25-Apr-91	07:41	13°49.7'S	112°20.7'W	893	893	1	8385	20	160	25	18.75
	115	25-Apr-91	09:57	13°47.0'S	112°31.8'W	898	898	405					
SEPR-62	115	25-Apr-91	12:18	13°48.9'S	112°26.2'W	899	87	1	8385	20	160	25	18.75
	115	25-Apr-91	15:09	14°01.3'S	112°29.4'W	906	594	504					
SEPR-63	115	25-Apr-91	17:45	14°04.3'S	112°23.5'W	907	173	1	8385	20	160	25	18.75
	115	25-Apr-91	20:16	14°01.2'S	112°36.2'W	913	626	446					
SEPR-64	115	25-Apr-91	22:21	14°06.6'S	112°35.4'W	914	1002	1	8385	20	160	25	18.75
	116	26-Apr-91	00:57	14°00.9'S	112°24.3'W	920	1425	351+					
SEPR-65	116	26-Apr-91	03:00	14°13.7'S	112°27.9'W	921	1836	1	8385	20	160	25	18
	116	26-Apr-91	05:00	14°11.4'S	112°37.5'W	926	2195	360					
SEPR-66	116	26-Apr-91	06:49	14°16.6'S	112°39.0'W	927	2524	1	8385	20	160	25	18
	116	26-Apr-91	09:27	14°19.3'S	112°26.1'W	933	2998	475					
SEPR-67	116	26-Apr-91	11:17	14°23.1'S	112°30.5'W	934	3329	1	8385	20	160	25	18
	116	26-Apr-91	13:36	14°20.6'S	112°40.9'W	939	3744	416					
SEPR-68	116	26-Apr-91	15:22	14°25.8'S	112°40.8'W	940	4065	1	8385	20	160	25	18
	116	26-Apr-91	17:42	14°28.6'S	112°29.4'W	945	4484	420					
SEPR-69	116	26-Apr-91	20:57	14°22.0'S	112°24.7'W	946	5426	1	4193	10	160	25	8.7
	117	27-Apr-91	02:55	14°15.0'S	112°53.1'W	962	7573	2144					
SEPR-70	117	27-Apr-91	04:50	14°10.2'S	112°51.3'W	963	8153	1	8385	20	160	25	18
	117	27-Apr-91	12:17	14°18.8'S	112°17.7'W	982	9493	1341					
SEPR-71	117	27-Apr-91	14:22	14°13.6'S	112°18.3'W	983	9946	1	~4000	10	160	25	8.7
	117	27-Apr-91	20:08	14°06.4'S	112°46.6'W	998	12019	2064					
SEPR-72	117	27-Apr-91	22:31	14°02.3'S	112°42.4'W	999	12751	13	~8200	20	160	25	18
	118	28-Apr-91	03:48	14°09.5'S	112°34.3'W	1012	13685	947					

Appendix 2 EW 91-02 Sonobuoy Log

S.B. #	J.D.	Date	Line #	Start Time (Z)	Tape #	Approx. Shot #	Latitude	Longitude	End Time (Z)	Tape #	Comments
1	96	6-Apr-91	SEPR-3	01:53	26	5676	20°08.5'S	113°43'W	03:47	31	
2	96	6-Apr-91	SEPR-3	03:53	32	6402	19°53'S	113°40'W			
3	96	6-Apr-91	SEPR-5	19:15	58	11925	19°26.5'S	113°33'W	21:13	63	AMC event
4	96	6-Apr-91	SEPR-5	21:54	65	12883	19°13'S	113°30'W			
5	97	7-Apr-91	SEPR-5	02:24	77	14500	18°51.1'S	113°26.7'W	04:34	83	
6	97	7-Apr-91	SEPR-5	04:42	84	15329	18°40.2'S	113°24'W	06:05	87	AMC event
7	97	7-Apr-91	SEPR-7	19:18	109	20599	18°26.9'S	113°23.7'W			AMC event
8	98	8-Apr-91	SEPR-9	06:34	125	24647	18°12.7'S	113°21.2'W	08:37	130	
9	98	8-Apr-91	SEPR-9	09:49	134	25810	17°57'S	113°18'W	12:00	139	18°02 OSC
10	98	8-Apr-91	SEPR-9	14:19	146	27430	17°35.4'S	113°14.8'W	16:05	151	
11	98	8-Apr-91	SEPR-9	16:50	152	28382	17°23.8'S	113°11.6'W	18:41		
12	98	8-Apr-91	SEPR-9	18:42	157	29040	17°14.6'S	113°09.7'W	20:50	163	
13	100	10-Apr-91	SEPR-13	22:54	225	44362	17°26.1'S	113°15.8'W			ESP 2
14	101	11-Apr-91	SEPR-14	08:30	252	46058	17°26.9'S	113°13.8'W		254	ESP 3
15	102	12-Apr-91	SEPR-17	01:57	282	49200	17°31.4'S	113°13.3'W			ESP 4
16	102	12-Apr-91	SEPR-17	05:31	291	49840	17°13'S	113°09'W	07:13	296	ESP 4
17	102	12-Apr-91	SEPR-18	10:34	299	50749	17°11.6'S	113°02.9'W		307	ESP 7
18	102	12-Apr-91	SEPR-19	19:30	311	52357	17°32.6'S	113°05.8'W			ESP 8
19	103	13-Apr-91	SEPR-20	03:15	329	53776	17°13.1'S	112°58.6'W			ESP 9
20	103	13-Apr-91	SEPR-21	11:46	355	55287	17°31.1'S	112°58'W			ESP 10
21	107	17-Apr-91	SEPR-35	01:10	492	11168	17°27.4'S	113°12.9'W		497	
22	107	17-Apr-91	SEPR-35	03:48	498	11642	17°14.8'S	113°09.9'W		498	Bad Buoy
23	107	17-Apr-91	SEPR-35	04:36	500	11785	17°11.4'S	113°08.8'W		506	
24	107	17-Apr-91	SEPR-35	08:19	508	12456	16°53.8'S	113°05.3'W	09:56	512	
25	107	17-Apr-91	SEPR-35	12:23	518	13188	16°34.8'S	113°03.2'W		520	
26	107	17-Apr-91	SEPR-35	16:36	527	13947	16°14.7'S	112°59.9'W			
27	109	19-Apr-91	SEPR-45	16:54	607	22642	15°49.6'S	112°57.6'W			Bad Buoy?
28	109	19-Apr-91	SEPR-45	19:50	613	23168	15°35.7'S	112°54.4'W			AMC event

S.B. #	J.D.	Date	Line #	Start Time (Z)	Tape #	Approx. Shot #	Latitude	Longitude	End Time (Z)	Tape #	Comments
29	109	19-Apr-91	SEPR-45	22:25	619	23635	15°23.8'S	112°51.4'W			Poor Buoy
30	110	20-Apr-91	SEPR-45	03:52	632	24615	14°58.0'S	112°44.2'W			
31	110	20-Apr-91	SEPR-45	07:03	639	25186	14°43.1'S	112°40.0'W		644	AMC event
32	110	20-Apr-91	SEPR-45	10:44	647	25851	14°25.9'S	112°35.9'W		651	
33	110	20-Apr-91	SEPR-45	13:18	653	26312	14°13.6'S	112°32.3'W			
34	111	21-Apr-91	SEPR-47	07:08	685	30643	14°16.2'S	112°47.0'W			ESP 15
35	111	21-Apr-91	SEPR-48	12:25	695	31592	14°26.0'S	112°43.8'W			ESP 16
36	112	22-Apr-91	SEPR-51	11:49	749	35805	14°08.9'S	112°29.6'W			ESP 20
37	115	25-Apr-91	SEPR-60	00:54	880	44744	13°27.0'S	112°21.0'W			Bad Buoy
38	115	25-Apr-91	SEPR-60	03:14	886	48160	13°38.4'S	112°23.7'W			Good Buoy
39	115	25-Apr-91	SEPR-62	12:25	899	108	13°49.2'S	112°26.3'W			

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-1	100	10-Apr-91	16:30	193	16:45	184	17:00	"	17:15	020
			16:31	193	16:46	172	17:01	027	17:16	020
			16:32	193	16:47	147	17:02	026	17:17	020
		abeam	16:33	193	16:48	123	17:03	025	17:18	019
		16:48:47	16:34	193	16:49	093	17:04	025	17:19	019
			16:35	193	16:50	076	17:05	024	17:20	019
			16:36	193	16:51	062	17:06	023	17:21	019
			16:37	193	16:52	052	17:07	023	17:22	
			16:38	193	16:53	044	17:08	023	17:23	
			16:39	193	16:54	040	17:09	022	17:24	
			16:40	193	16:55	037	17:10	022	17:25	
			16:41	193	16:56	034	17:11	021		
			16:42	193	16:57	032	17:12	021		
			16:43	193	16:58	on radio	17:13	021		
			16:44	191	16:59	"	17:14	020		
ESP-2	101	11-Apr-91	00:13	013	00:28	262	00:43	206		
			00:14	012	00:29	248	00:44	205		
			00:15	010	00:30	238	00:45	205		
		abeam	00:16	009	00:31	232	00:46	203		
		0:26:21	00:17	007	00:32	227	00:47	203		
			00:18	004	00:33	222	00:48	202		
			00:19	002	00:34	219	00:49	201		
			00:20	358	00:35	217	00:50	201		
			00:21	353	00:36	215	00:51	200		
			00:22	347	00:37	213	00:52	200		
			00:23	338	00:38	212	00:53	200		
			00:24	326	00:39	210	00:54			
			00:25	312	00:40	210	00:55			
			00:26	294	00:41	208				
			00:27	278	00:42	207				

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-3	101	11-Apr-91	06:40	194	06:55	188	07:10	049	07:25	023
			06:41	194	06:56	186	07:11	045	07:26	022
			06:42	194	06:57	184	07:12	042	07:27	021
		abeam	06:43	194	06:58	181	07:13	039	07:28	020
		7:04:50	06:44	194	06:59	177	07:14	036	07:29	019
			06:45	194	07:00	171	07:15	034	07:30	019
			06:46	193	07:01	164	07:16	033	07:31	018
			06:47	193	07:02	153	07:17	031	07:32	017
			06:48	193	07:03	138	07:18	030	07:33	017
			06:49	193	07:04	120	07:19	029	07:34	016
			06:50	193	07:05	102	07:20	028	07:35	016
			06:51	193	07:06	085	07:21	027	07:36	015
			06:52	192	07:07		07:22	026	07:37	015
			06:53	191	07:08	063	07:23	025	07:38	
			06:54	190	07:09	055	07:24	024		
ESP-4	102	12-Apr-91	04:04	013	04:19	006	04:34	205		
			04:05	013	04:20	003	04:35	204		
			04:06	013	04:21	000	04:36	203		
		abeam	04:07	013	04:22	355	04:37	202		
		4:26:00	04:08	013	04:23	348	04:38	201		
			04:09	013	04:24	332	04:39	200		
			04:10	013	04:25	314	04:40	206		
			04:11	013	04:26	287	04:41	199		
			04:12	013	04:27	256	04:42	199		
			04:13	013	04:28	237	04:43	199		
			04:14	012	04:29	223	04:44	198		
			04:15	011	04:30		04:45	197		
			04:16	010	04:31		04:46	196		
			04:17	009	04:32	209	04:47	196		
			04:18	008	04:33		04:48	195		

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-5	101	11-Apr-91	15:00	015	15:15	338	15:30	206	15:45	195
			15:01	015	15:16	323	15:31	205		
			15:02	015	15:17	302	15:32	204		
		abeam	15:03	015	15:18	275	15:33	204		
		15:17:23	15:04	015	15:19	260	15:34	203		
		0.4nm CPA	15:05	015	15:20	245	15:35	202		
			15:06	015	15:21	234	15:36	201		
			15:07	013	15:22	228	15:37	200		
			15:08	011	15:23	222	15:38	199		
			15:09	010	15:24	218	15:39	198		
			15:10	008	15:25	215	15:40	197		
			15:11	005	15:26	213	15:41	197		
			15:12	001	15:27	211	15:42	196		
			15:13	356	15:28	209	15:43	195		
			15:14	349	15:29	207	15:44	195		
ESP-6	101	11-Apr-91	21:30	191	21:45	125	22:00	039	22:15	
			21:31	190	21:46	107	22:01	038	22:16	
			21:32	190	21:47	092	22:02	037	22:17	
		abeam	21:33	190	21:48	on radio	22:03	033	22:18	
		13:47:00	21:34	189	21:49	067	22:04	032	22:19	
		0.6nm CPA	21:35	188	21:50	057	22:05	029	22:20	015
			21:36	186	21:51	049	22:06	028		
			21:37	183	21:52	045	22:07	027		
			21:38	181	21:53	041	22:08			
			21:39	178	21:54	038	22:09			
			21:40	174	21:55	035	22:10			
			21:41	169	21:56	035	22:11			
			21:42	162	21:57	036	22:12			
			21:43	152	21:58	039	22:13			
			21:44	140	21:59	040	22:14			

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-7	102	12-Apr-91	12:33	195	12:48	138	13:03	024	13:18	012
			12:34	195	12:49	119	13:04	023	13:19	012
			12:35	194	12:50	098	13:05	022	13:20	012
		abeam	12:36	194	12:51	080	13:06	021		
		12:50	12:37	193	12:52	066	13:07	020		
			12:38	192	12:53	056	13:08	019		
			12:39	191	12:54	048	13:09	018		
			12:40	190	12:55	043	13:10	017		
			12:41	187	12:56	038	13:11	016		
			12:42	185	12:57	035	13:12	015		
			12:43	181	12:58		13:13	014		
			12:44	178	12:59		13:14			
			12:45	172	13:00	028	13:15	013		
			12:46	164	13:01	026	13:16	012		
			12:47	153	13:02	025	13:17	012		
ESP-8	102	12-Apr-91	21:30	014	21:45	357	22:00	227	22:15	202
			21:31	014	21:46	353	22:01	224	22:16	
			21:32	014	21:47	346	22:02	220	22:17	200
		abeam	21:33	014	21:48	338	22:03	218	22:18	200
		21:51:20	21:34	014	21:49	329	22:04	217	22:19	199
		0.6nm CPA	21:35	014	21:50	314	22:05	215	22:20	199
			21:36	014	21:51	302	22:06			
			21:37	014	21:52	287	22:07	211		
			21:38	014	21:53	273	22:08	210		
			21:39	013	21:54	261	22:09	209		
			21:40	011	21:55	252	22:10	208		
			21:41	010	21:56	245	22:11	207		
			21:42	008	21:57	239	22:12	205		
			21:43	005	21:58	234	22:13	204		
			21:44	001	21:59	230	22:14	203		

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-9	103	13-Apr-91	05:00	195	05:15	164	05:30	028		
			05:01	195	05:16	152	05:31	027		
			05:02	195	05:17	138	05:32	025		
		abeam	05:03	195	05:18	116	05:33	024		
		5:19:10	05:04	194	05:19	101	05:34	024		
		0.4nm CPA	05:05	194	05:20	082	05:35	022		
			05:06	193	05:21	066	05:36	021		
			05:07	192	05:22	055	05:37	020		
			05:08	191	05:23	047	05:38	020		
			05:09	189	05:24	042	05:39	019		
			05:10	187	05:25	038	05:40	018		
			05:11	185	05:26	035	05:41	017		
			05:12	182	05:27	033	05:42	017		
			05:13	178	05:28	030	05:43			
			05:14	173	05:29	029	05:44			
ESP-10	103	13-Apr-91	13:10	015	13:25	343	13:40	208	13:55	196
			13:11	015	13:26	329	13:41	207	13:56	196
			13:12	015	13:27	310	13:42	206		
		abeam	13:13	015	13:28	289	13:43	205		
		13:27:53	13:14	015	13:29	263	13:44	205		
			13:15	015	13:30	251	13:45	204		
			13:16	015	13:31	239	13:46	202		
			13:17	014	13:32	230	13:47	202		
			13:18	013	13:33	225	13:48	200		
			13:19	012	13:34	221	13:49	199		
			13:20	010	13:35	217	13:50	198		
			13:21	007	13:36	215	13:51	198		
			13:22	003	13:37	212	13:52	197		
			13:23	359	13:38	211	13:53	197		
			13:24	353	13:39	209	13:54	196		

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-11	103	13-Apr-91	22:02	192	22:17	183	22:32	025		
			22:03	192	22:18	176	22:33	024		
			22:04	192	22:19	170	22:34	023		
		abeam	22:05	192	22:20	164	22:35	021		
		22:25:10	22:06	192	22:21	155	22:36	020		
		0.3nm CPA	22:07	192	22:22	148	22:37	020		
			22:08	192	22:23	ost targe	22:38	019		
			22:09	192	22:24	127	22:39	019		
			22:10	192	22:25	095				
			22:11	191	22:26	070				
			22:12	190	22:27	053				
			22:13	189	22:28	042				
			22:14	188	22:29	035				
			22:15	186	22:30	031				
			22:16	185	22:31	026				
ESP-12	104	14-Apr-91	02:30	014	02:45	330	03:00	206		
			02:31	014	02:46	310	03:01	205		
			02:32	013	02:47	288	03:02	204		
		abeam	02:33	013	02:48	267	03:03	203		
		2:46:49	02:34	013	02:49	246	03:04			
		0.6nm CPA	02:35	011	02:50	226	03:05	202		
			02:36	010	02:51		03:06	202		
			02:37	009	02:52	221				
			02:38	007	02:53	217				
			02:39	005	02:54	214				
			02:40	002	02:55	212				
			02:41	359	02:56	210				
			02:42	355	02:57	209				
			02:43	350	02:58	208				
			02:44	341	02:59	207				

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-13	104	14-Apr-91	08:40	101	08:55	032	09:10	295	09:25	283
			08:41	101	08:56	014	09:11	294		
			08:42	101	08:57	356	09:12	293		
		abeam	08:43	100	08:58	341	09:13	292		
		08:56:??	08:44	099	08:59	329	09:14	291		
			08:45	097	09:00	321	09:15	290		
			08:46	095	09:01	316	09:16	289		
			08:47	093	09:02	311	09:17	288		
			08:48	090	09:03	307	09:18	287		
			08:49	087	09:04	304	09:19	286		
			08:50	083	09:05	302	09:20	286		
			08:51	078	09:06	300	09:21	285		
			08:52	071	09:07	298	09:22	284		
			08:53	062	09:08	297	09:23	283		
			08:54	048	09:09	296	09:24	283		
ESP-14	104	14-Apr-91	15:32	193	15:47	172	16:02	023	16:17	015
			15:33	193	15:48	163	16:03	022	16:18	015
			15:34	193	15:49	146	16:04	022		
		abeam	15:35	193	15:50	119	16:05	021		
		15:50:35	15:36	193	15:51	087	16:06	021		
			15:37	192	15:52	062	16:07	020		
			15:38	192	15:53	048	16:08	019		
			15:39	191	15:54	039	16:09	018		
			15:40	190	15:55	035	16:10	018		
			15:41	189	15:56	031	16:11	017		
			15:42	187	15:57	029	16:12	017		
			15:43	186	15:58	027	16:13	016		
			15:44	184	15:59	026	16:14	016		
			15:45	181	16:00	024	16:15	015		
			15:46	177	16:01	024	16:16	015		

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-15	111	21-Apr-91	06:09		06:24	145	06:39	026		
			06:10		06:25	129	06:40	025		
			06:11		06:26	111	06:41	025		
		abeam	06:12		06:27	092	06:42	022		
		6:26:30	06:13		06:28	072	06:43	021		
			06:14	188	06:29	062	06:44	020		
			06:15	187	06:30	053	06:45	019		
			06:16		06:31	046	06:46	018		
			06:17	185	06:32	041	06:47	017		
			06:18	183	06:33	037	06:48	016		
			06:19	180	06:34	034	06:49	015		
			06:20	177	06:35	033	06:50	015		
			06:21	172	06:36	030	06:51	014		
			06:22	166	06:37	028	06:52	014		
			06:23	157	06:38	027	06:53	014		
ESP-16	111	21-Apr-91	15:05	017?	15:19	358	15:34	216	15:49	199
			15:06	017?	15:20	352	15:35	215	15:50	199
			15:07	018?	15:21	344	15:36	213	15:51	198
		abeam	15:08	017?	15:22	333	15:37	212	15:52	197
		15:24:30	15:09	017?	15:23	318	15:38	211	15:53	196
			15:10	017?	15:24	301	15:39	209	15:54	196
			15:11	019	15:25	283	15:40	208	15:55	195
			15:12	020	15:26	267	15:41	207		
			15:13	015	15:27	254	15:42	207		
			15:14	012	15:28	244	15:43	205		
			15:15	010	15:29	236	15:44	204		
			15:16	009	15:30	230	15:45	203		
			15:17	006	15:31	226	15:46	202		
			15:18	002	15:32	223	15:47	201		
			15:19	358	15:33	219	15:48	200		

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-17	112	22-Apr-91	00:00	193	00:15	183	00:30	lost	00:45	016
			00:01	193	00:16	180	00:31	target		
			00:02	193	00:17	176	00:32			
		abeam	00:03	193	00:18	171	00:33	026		
		0:22:57	00:04	193	00:19	163	00:34	025		
			00:05	192	00:20	152	00:35	024		
			00:06	192	00:21	137	00:36	023		
			00:07	192	00:22	118	00:37	023		
			00:08	192	00:23	094	00:38	022		
			00:09	191	00:24	075	00:39	020		
			00:10	191	00:25	059	00:40	019		
			00:11	190	00:26	049	00:41	018		
			00:12	189	00:27	042	00:42	017		
			00:13	188	00:28	037	00:43	017		
			00:14	186	00:29	034	00:44	016		
ESP-18	112	22-Apr-91	07:03	013	07:18	335	07:33	210	07:48	198
			07:04	013	07:19	323	07:34	208	07:49	197
			07:05	013	07:20	307	07:35	207	07:50	197
		abeam	07:06	012	07:21	289	07:36	207		
		7:21:20	07:07	012	07:22	270	07:37	206		
			07:08	011	07:23	255	07:38	205		
			07:09	010	07:24	243	07:39	204		
			07:10	008	07:25	234	07:40	203		
			07:11	007	07:26	227	07:41	203		
			07:12	005	07:27	220	07:42	201		
			07:13	003	07:28	219	07:43	201		
			07:14	359	07:29	216	07:44	200		
			07:15	356	07:30	214	07:45	199		
			07:16	351	07:31	213	07:46	199		
			07:17	344	07:32	211	07:47	198		

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-19	112	22-Apr-91	18:35	015	18:50	005	19:05	206		
			18:36	015	18:51	000	19:06	205		
			18:37	015	18:52	352	19:07	204		
		abeam	18:38	015	18:53	341	19:08	204		
		18:55:15	18:39	015	18:54	320	19:09	203		
		0.25 nm CPA	18:40	015	18:55	283	19:10	202		
		(baloney	18:41	015	18:56	256	19:11	201		
		launch)	18:42	014	18:57	237	19:12	on radio		
			18:43	013	18:58	226	19:13	"		
			18:44	012	18:59	219	19:14	"		
			18:45	011	19:00	215	19:15	"		
			18:46	010	19:01	212	19:16	"		
			18:47	010	19:02	210	19:17	"		
			18:48	008	19:03	208	19:18	"		
			18:49	007	19:04	207	19:19	197		
ESP-20	112	22-Apr-91	13:08	194	13:23	127	13:38	028		
			13:09	193	13:24	112	13:39	027		
			13:10	193	13:25	097	13:40	026		
		abeam	13:11	192	13:26	081	13:41	025		
		13:24:30	13:12	190	13:27	068	13:42	024		
			13:13	189	13:28	059	13:43	022		
			13:14	187	13:29	052	13:44	022		
			13:15	185	13:30	046	13:45	021		
			13:16	182	13:31	042	13:46	020		
			13:17	179	13:32	039	13:47	019		
			13:18	175	13:33	036	13:48	018		
			13:19	169	13:34	034	13:49	018		
			13:20	163	13:35	032	13:50	017		
			13:21	153	13:36	031	13:51	017		
			13:22	141	13:37	029	13:52	016		

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-21	113	23-Apr-91	01:25	195	01:40	180	01:55	030	02:10	014
			01:26	195	01:41	175	01:05	028		
			01:27	195	01:42	168	01:57	027		
		abeam	01:28	195	01:43	158	01:58	026		
		1:45:48	01:29	195	01:44	143	01:59	025		
		0.4nm CPA	01:30	195	01:45	124	02:00	024		
			01:31	195	01:46	098	02:01	024		
			01:32	195	01:47	079	02:02	022		
			01:33	194	01:48	068	02:03	021		
			01:34	193	01:49	058	02:04	020		
			01:35	192	01:50	044	02:05	019		
			01:36	190	01:51	041	02:06	017		
			01:37	188	01:52	036	02:07	016		
			01:38	186	01:53	034	02:08	015		
			01:39	183	01:54	031	02:09	015		
ESP-22	113	23-Apr-91	08:24	014	08:39	341	08:54	208	09:09	195
			08:25	014	08:40	329	08:55	207		
			08:26	014	08:41	314	08:56	206		
		abeam	08:27	014	08:42	295	08:57	205		
		8:42:40	08:28	014	08:43	274	08:58	205		
			08:29	014	08:44	255	08:59	203		
			08:30	013	08:45	244	09:00	202		
			08:31	012	08:46	237	09:01	201		
			08:32	010	08:47	227	09:02	200		
			08:33	008	08:48	221	09:03	199		
			08:34	006	08:49	217	09:04	198		
			08:35	003	08:50	214	09:05	198		
			08:36	000	08:51	212	09:06	197		
			08:37	355	08:52	210	09:07	196		
			08:38	349	08:53	209	09:08	196		

ESP#	J.D.	Date	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)	Time (Z)	Bearing (Degrees)
ESP-23	113	23-Apr-91	11:33	191	11:48	123	12:03	029	12:18	016
			11:34	191	11:49	108	12:04	028		
			11:35	191	11:50	092	12:05	027		
		abeam	11:36	190	11:51	079	12:06	026		
		11:48:50	11:37	188	11:52	073	12:07	025		
			11:38	187	11:53	061	12:08	024		
			11:39	185	11:54	051	12:09	023		
			11:40	182	11:55	049	12:10	022		
			11:41	180	11:56	045	12:11	021		
			11:42	176	11:57	041	12:12	020		
			11:43	171	11:58	038	12:13	019		
			11:44	165	11:59	036	12:14	019		
			11:45	158	12:00	034	12:15	018		
			11:46	149	12:01	032	12:16	017		
			11:47	137	12:02	030	12:17	017		