CRUISE REPORT

R/V MAURICE EWING - CRUISE 9210

SEPTEMBER 29TH TO NOVEMBER 9TH 1992

BRIDGETOWN, BARBADOS TO ST. GEORGES, BERMUDA

FARA MICROEARTHQUAKE EXPERIMENTS ON THE MID-ATLANTIC RIDGE NEAR 29°N and 35N°

G.M. PURDY
WOODS HOLE OCEANOGRAPHIC INSTITUTION
WOODS HOLE, MA 02543
&
D.R. TOOMEY
UNIVERSITY OF OREGON
EUGENE, OR 97403

"This should never happen" [1]

[1]: *System and Network Administration Manual, Chapter 24 -File System Check Program Revision A March 27, page 767, SUN Microsystems Inc.,1990.*

SUMMARY 1
INTRODUCTION 6
SCIENTIFIC OBJECTIVES 7
OPERATIONAL OBJECTIVES 7
NARRATIVE 8
PRELIMINARY ASSESSMENT OF FARA.01 RESULTS 15
Activity levels and Event Counts 15
Some Event Characteristics 23
APPENDICES 27
Appendix 1 Science Complement and Crew List 28
Appendix 2 Table of OBS Recoveries FARA 01 29
Appendix 3 Table of OBS Deployments FARA 02 30
Appendix 4 The Loss of OBS #55 31
Appendix 5 The Research Vessel MAURICE EWING 33
Appendix 6 OBS Performance during FARA.01 Part 1 35
Performance by Instrument 35
Performance Tables 62
FARA 01 Clock Drift Corrections 65
FARA 02 OBS Pre-Deployment Clock Checks 68
Modifications to the Hydrophone Pre-amplifier 70
Maxtor Recorder Issues 74
GRA spikes and Grounding 84
The OBS Control Loop 85
The 100MB Lab Test 87
Appendix 7 OBS Performance during FARA 01 Part 2 89
Summary 89
Appendix 8 FARA 02 Test 91
Appendix 9 Examples of Good Data from FARA 01 99
Appendix 10 New Check Lists 111
Appendix 11 Mechanical Modifications to the ONR OBS 125
Appendix 12 Acquisition Programs FARA.01&FARA.02 131
Appendix 13 FARA 01 Shot Table and Location Figures 132
Appendix 14 FARA 02 Airgun Shooting Tracks 145
Appendix 15 Data Handling and Processing 147
Data Handling on EW9210 147
Plans for a Matlab Microearthquake Data Reduction System 154
Appendix 16 Clocks 160
Appendix 17 EG&G Acoustics System 164
Appendix 18 Data List 165
Appendix 19 Hydrosweep Survey 167

SUMMARY

This is a technical report that describes the OBS (ocean bottom seismometer) operations carried out on board the Research Vessel MAURICE EWING during a 42 day long expedition to the Mid-Atlantic Ridge in October and November 1992 (Figure 1). The goal of the research that stimulated this cruise is to understand the earth processes controlling the creation of new lithosphere at the global mid-ocean ridge system. In this project microearthquake signals are recorded on a network of 14-15 ocean bottom seismometers for a period of 45-50 days on two contrasting segments of a typical slow-spreading ridge (the Mid-Atlantic Ridge). The objective is to elucidate the episodicity of crustal accretion by determining the nature of the tectonic and magmatic processes at one segment that is interpreted to be ' cold ' (latitude 29 N) and at a second that is thought to be ' hot ' and primarily controlled by magmatic processes (latitude 35 N). In August 1992 a network of 15 ONR ocean bottom seismometers was deployed on the ridge near latitude 29 N by the research vessel OCEANUS. On the cruise described in this report these instruments were recovered, a preliminary assessment of the recorded data was made, and they were redeployed (approximately 26 days later) on the northern segment of the ridge near latitude 35 N.

Because this was the first time the ONR OBS had been used in this mode of event detection on the extreme rough topography of the Mid-Atlantic Ridge many important lessons were learned concerning how best to function in this difficult environment. Recovery of the instruments from the first deployment (see Appendix 9 for the network configuration)was straightforward and trouble-free with the single notable exception that OBS #55 did not lift off from the seafloor (after it had properly responded to the release commands on both its release-transponders). We believe that this unit is trapped on the seafloor: even though its anchor has been properly released, it is unable to rise to the surface. Fortunately, our French colleagues, led by Dr. Jean-Marie Auzende, have agreed to dive on this instrument using the submersible NAUTILE in mid-November. It may be that the submersible will be unable to recover this OBS but most importantly we will be able to unequivocally determine the reason for the failure to rise from the seafloor.

Data return from the first deployment was controlled by the effects of instrument tilt due to rough seafloor topography. When the sensor package was tilted beyond the range of its gimbals the seismometers were unable to level, were against their stops and produced little useful data. If a seismometer was against the stops the grounding of the instrument was changed in such a way that the A-to-D generated spurious spikes on one second boundaries on all data channels. When the main instrument frame itself was tilted beyond 15 degrees in its longitudinal axis the optical disc drive was unable to operate properly causing it to hang-up and stop recording data.

A substantial volume of excellent data were collected during the FARA 01 deployment. One example of a set of seismograms generated by a nearby microearthquake is shown in Figure 2. Further examples of good seismograms are included in Appendix 9 On average about 1000 triggers per day occurred across the network. The vast majority were caused by natural seismic events. For example, on 24th August OBS #54 recorded 130 separate events and of these 90 were identified as microearthquakes. On 23rd September 80% of all the recorded events on OBS #54,59,61 and 63 were real microearthquakes.A large proportion of these events are tiny, too small to generate readable records on more than one or two instruments. Nevertheless, during the deployment period 1000 events triggered four or more OBSs and 200 events triggered six or more.Therefore, it is believed that, despite significant data loss caused by the rugged Mid-Atlantic Ridge topography, sufficient

high quality data have been collected to permit the active tectonics of this slow spreading ridge segment to be satisfactorily characterised.

Following recovery of the OBS from the FARA 01 deployment at the beginning of this cruise, the research vessel began a 24 day-long bathymetry, gravity and magnetics survey of the flanks of the ridge, the tracks for which are shown in Figure 1. This work was carried out under the leadership of Dr J-C Sempere of the University of Washington, Seattle. During this time the preliminary evaluation of the OBS data was carried out and modifications were made to the instruments specifically to enhance their performance in rugged terrain. Most notably the anchor configuration was changed so the instrument floats two feet above the seafloor and self-levels. The way the sensor package is deployed was also modified to delay the emplacement of the sensor until the OBS is firmly settled on the seabed. Several old hydrophone sensors were found to be defective and were replaced with newer units.

The site for the redeployment of the instruments was chosen to be a segment of the ridge near latitude 35N. All fourteen of the OBS were deployed in a network (shown in Figure 3) that began recording at 2100Z November 2nd. Approximately 23 hours were spent steaming at four knots in a tight grid of lines around the network firing a pair of airguns totalling 1600 cu in in capacity, to provide the water wave data necessary for accurate network location and to provide crustal refraction data to constrain the seismic structure of the uppermost crust. Approximately 20 hours was spent carrying out a multibeam bathymetry survey of the network site using the EWING's Hydrosweep system. As can be seen in Figure 3 this second network is characterised by smaller receiver spacings (nominally 4 km) than the first at 29N. This decision was a result of both the supposition that the activity at this so-called 'hot' segment would be shallower and therefore smaller OBS separations were necessary if good constraints on focal depths were desired; and because of the observations from the first deployment that clearly revealed the presence of a substantial level of very small events. The OBSs are scheduled to be recovered by the research vessel OCEANUS on or about December 23-24 1992.

For the first time a large network of digitally recording ocean bottom seismometers was recovered and redeployed for a major experiment on the same cruise leg. We learned that the magnitude of this effort is substantial but it is a tractable operation. Our past usage of ocean bottom hydrophones moored above the sea floor avoided many of the pitfalls associated with rough seafloor terrain that on this cruise caused us trouble. However we have considerable confidence that the approaches to solving these problems that were developed and implemented at sea will result in a successful experiment at 35N that will produce an even greater data set than that recorded at 29N. With the notable exception of the inoperative hydrophone sensors it is important to note that none of the data loss incurred during FARA 01 was due to a technical failure of the instruments as designed: no units failed because of human errors in instrument preparation or bad components.. The OBSs operated as they were designed to operate: it was the design that was at fault. Now that substantial progress has been made toward correcting that, we look forward in December to the recovery of an exceptional data set.

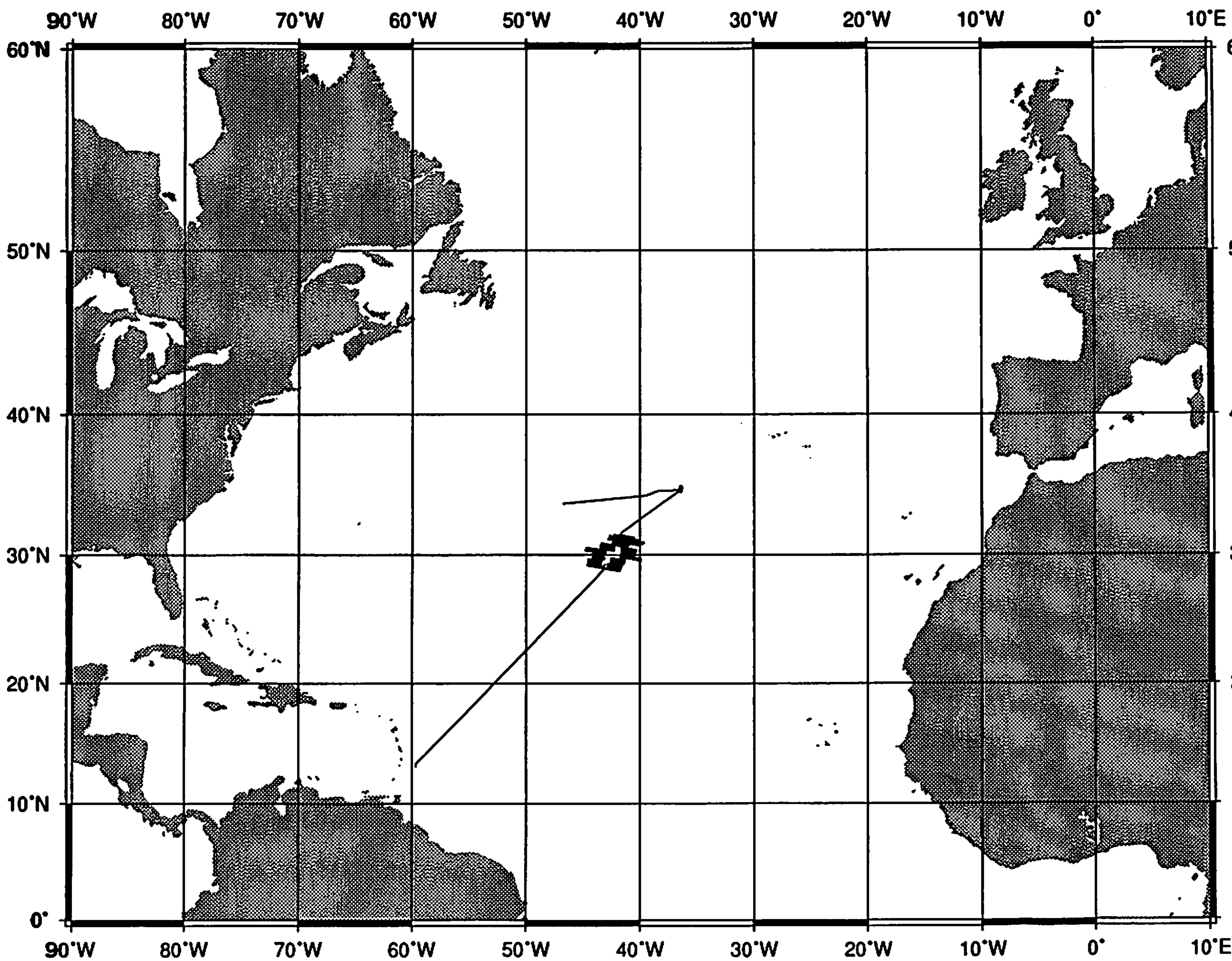

90°W
80°W
70°W
60°W
50°W
40°W
30°W
20°W
10°W
0°
10°E
60°N
50°N
40°N
30°N
20°N
10°N
0°

FIGURE 1

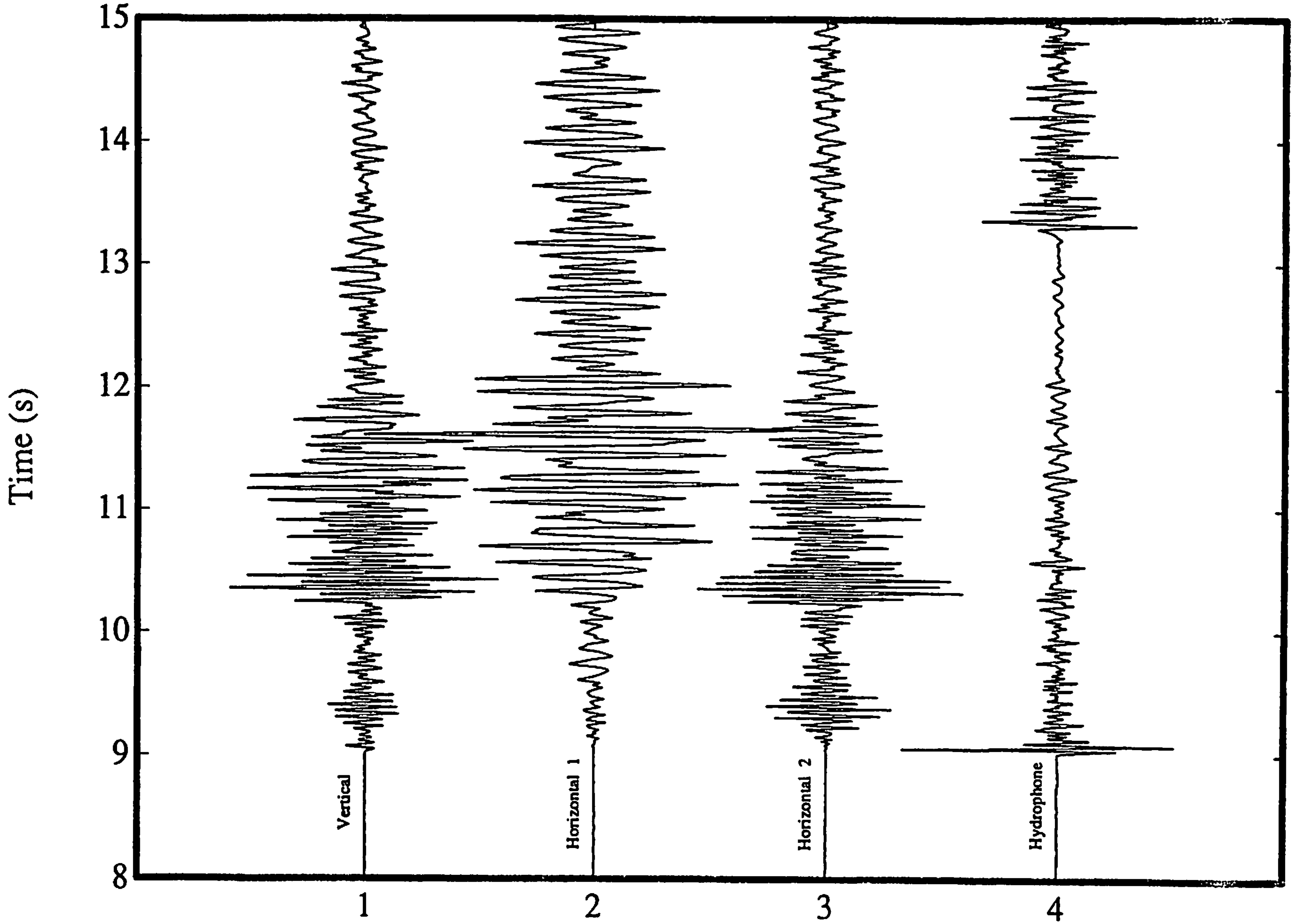
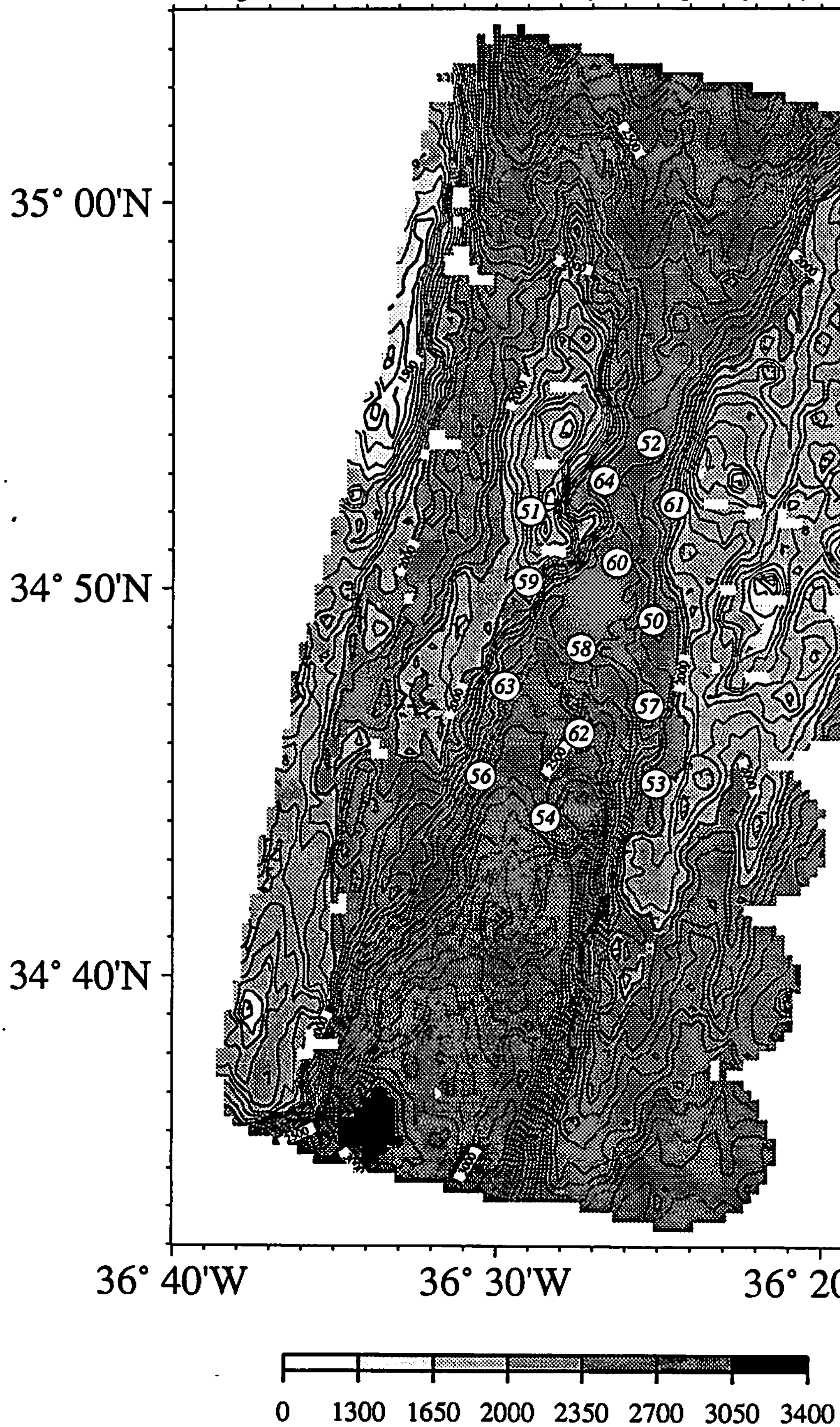


FIGURE 2: Example of a set of seismograms recorded by OBS #53 during FARA 01. Note the impulsive compressional first arrival on the hydrophone channel and the clearly identifiable shear waves arriving approximately one second after the P waves. The prominent event on the hydrophone channel four seconds after the first arrivals is the water multiple.

FIGURE 3 Locations of the fourteen redeployed OBS instruments on the crest of the Mid-Atlantic Ridge near 35N overlain on EWING Hydrosweep bathymetry data.



INTRODUCTION

This document was prepared in its entirety on board ship before arrival in Bermuda. It represents the most preliminary view of the data recorded during the experiment FARA 01, the objectives of which are described in the following two sections of this cruise report. The report is intended primarily as a reference document for the participants and for those who will be working on the interpretation of the data .It constitutes a technical record of the problems that were experienced with the OBS instrumentation and other shipboard hardware and contains descriptions of the solutions that were developed, written to provide constructive guidance for future OBS operations.

The OBS operations, to which this report is restricted, constituted only one part of the science activities during Cruise EW9210. Only eight days of the total of 42 spent at sea were assigned to this project. The remainder were spent carrying out multibeam echo sounding, gravity and magnetic surveys over the flanks of the Mid-Atlantic Ridge, under the direction of J-C Sempere of the University of Washington, Seattle.Of the total science complement of 20 listed in Appendix 1 only 8 (those affiliated with Woods Hole Oceanographic Institution and the University of Oregon) were concerned with the activities described in this report. Sean Solomon, the third co-principal investigator on this NSF funded project along with Mike Purdy and Doug Toomey, did not participate in the seagoing operations.

This introduction will describe the structure of this report so the reader can be guided quickly to the sections of interest. The Summary, that preceded this introductory section, provides a complete overview of all aspects of the cruise and can be comprehended without reference to other parts of the report. The briefest descriptions of both the scientific and operational objectives of the expedition are presented on the page following this. This is followed by a dry chronological account of the operations that were performed on the vessel day-by-day. If the desire is to determine when something occurred, or find out the order in which some set of operations were carried out then this is the section to read. This is followed by a preliminary overview of the data that were collected and a brief description of some of the results of the shipboard data reduction activities.

All the detailed information is contained in one of the 18 Appendices. OBS recovery and deployment times and locations are given in Appendices 2 and 3. The technical descriptions of OBS problems and modifications can be found in Appendices 6,7 and 11.(Appendices 6 and 11 provide the engineering details, and Appendix 7 provides the broad less quantitative overview.) Comments about the research vessel herself, and the effectiveness or otherwise of our operations on board, are provided in Appendix 5. Important events, like the non-recovery of OBS #55 (Appendix 4)and the test deployment (Appendix 8) receive detailed treatment in their own appendices. Results of controlled source activities are contained in Appendices 13 and 14 and descriptions of how the data were handled on board and how we would like to handle the data on future operations, may be found in Appendix 15.

It was possible to redeploy our OBS's on such a strongly contrasting ridge segment only because of the valuable co-operation of our French colleague Dr. D. Needham of IFREMER who provided excellent large scale advance copies of his multi-beam bathymetry survey of the ridge segment just south of 35 degrees north that is subjectively judged to be one of the 'hottest' and potentially most volcanically active segments of the Mid-Atlantic Ridge that has been surveyed to date.

Substantial contributions to this cruise report were made by John Hallinan,Cecily Wolfe, Beecher Wooding, Andrew Barclay, David DuBois and John Bailey.

The success of our cruise depended upon effective co-operation between the two groups of scientists on board the vessel. It was a pleasure and a privilege to work with Dr. J-C Sempere and his team. We received total co-operation in every respect and greatly valued their help with watch-keeping and with the very difficult process of editing the Hydrosweep multibeam data.

SCIENTIFIC OBJECTIVES

- Determine the spatial distribution and source mechanisms of microearthquake activity beneath a typical section of the Mid-Atlantic Ridge that is characterized by a simple well-developed median valley.

- Determine the spatial distribution and source mechanisms of microearthquake activity beneath a typical section of the Mid-Atlantic Ridge that is *not* characterized by a well-developed median valley.

- Perform a comparison of the active tectonics of a ridge segment that is presumed to be in a 'cold' non-magmatic stage, with one that is, or has been in the recent past, volcanically active.

- Gain insights into the nature of the episodicity of the crustal accretion process through comparisons of this first microearthquake experiment with existing datasets and, most importantly with the results of the second deployment carried out on this cruise that took place on a section of the ridge that does not exhibit a well-developed median valley.

- Determine the seismic velocity structure beneath the median valley, and particularly map any systematic along-axis variations in that structure.

OPERATIONAL OBJECTIVES

- Recover fifteen ONR OBS that were deployed in August from the Research vessel OCEANUS on the Mid-Atlantic Ridge near 29N.

- Assess data quality from this deployment and make the repairs and modifications necessary to ensure high quality data return on the redeployment.

- Deploy fifteen ONR OBS in and adjacent to the Median valley of the Mid-Atlantic Ridge near latitude 35N.

- Using an airgun source fire a sufficient number of adequately distributed shots to permit the determination of both the precise location of the OBS instruments and the orientation of their sensor packages.

- Fire a pattern of airgun shots over the OBS network designed to image the shallowmost structure of the crust beneath the median valley.

NARRATIVE

The WHOI team flew down to Barbados on Thursday 24th September 1992 and met the MAURICE EWING upon its arrival in Bridgetown on the 25th. The next three days were spent installing equipment in the labs on board and preparing for sea. We sailed from Barbados on schedule at approximately 10am LT on Tuesday 29th September, with a full science complement.,(see Appendix 1), bound for the Mid-Atlantic Ridge near 29N. The weather was excellent: hot, sunny and calm. Primary activities during the 5 day passage were the meticulous preparation for the instrument recoveries and the frustrating and extremely time consuming task of attempting to find and correct an apparent fault in the gigabyte disc drive on Doug Toomey's Sun system

The vessel made good speed and we arrived on site ready to begin OBS recovery operations at 0900LT,Sunday 4th October.Unfortunately the wind speed had increased to 20-25knots overnight and the seas had begun to build. Motion onboard EWING remained minimal, however, and the release procedures continued despite the limited visibility in the rain squalls. After the second recovery, OBS 58, serious consideration was given to the possibility of abandoning operations until the weather improved, but conditions stabilized with a 20-25 knot wind and the decision was made to continue.It was not easy to maneuver the vessel for the pick-ups but no particular difficulties were experienced.Especially in bad visibility the radio beacons were of considerable help in locating the surfaced units. Our surface time predictions were generally good to 2-3 minutes and all the units appeared within 200-300 meters of the ship or less. After the first few recoveries we knew a significant problem existed with the instrument levelling: the rust spot level indicators (RSLI's) showed that many of the sensor packages had been sitting at an angle outside of the range in which the gimbals could maintain the seismometers level (for details see Appendix 6).

On this first day we recovered seven OBS as planned ending at around 0130 am ships time, when we stopped for a few hours rest and the ship steamed off to carry out a brief 4-5 hour long Hydrosweep.survey under the direction of J-C Sempere. Our EG&G 8011A deck unit failed during the sixth release procedure and we switched over to the trusty 8011 unit.

Recoveries recommenced at 0730am on Monday 5th. October. The order of recovery of all the units is given in Appendix 2 and an overview of the instrument performance is presented in Appendix 6 Disaster struck during our second recovery of the morning: OBS #55, after acknowledging receipt of release commands on both transponder-release units with the affirmative 1 second timed ping, remained on the seafloor. This should never happen. Details are given in Appendix 4 We continued to the recoveries of OBS's #64 and 60 and returned to #55, but it was clearly still on the seafloor. After recovering the final OBS soon after midnight we returned once again to #55 but to no avail. At approximately 0100 am we handed control of the ship back to Chief Scientist J-C Sempere and he began the 24 day long Hydrosweep,gravity and magnetics survey of the flanks of the Mid-Atlantic Ridge. The OBS group began the long and important task of assessing the data quality and planning the changes and improvements that would be necessary to the OBS before they could be redeployed on the 31st October.One good piece of news was that all the recovered OBS passed their electronics checks when they were brought on board. The primary problem that severely restricts the size of the recorded data set is that more than half the units were significantly off level in the rough topography of the median valley (see Appendix 6 for detail).

Tuesday 6th October was spent starting the Hydrosweep survey on the western flank of the ridge. The effectiveness of EWING's email communications began to be realised for the first time as significant numbers of messages began arriving telling of problems and difficulties ashore. As if we did not have enough of our own problems.......

The major positive event of the day was the successful resurrection of Doug Toomey's SUN. LDGO systems technician Budhypramano successfully loaded a new system on to the workstation disc drive and normal reliable operation was at last possible.The first backups of the OBS data from the Maxtor discs onto Exabyte tape cartridges were successfully completed on the following day and preliminary tables of the recorded event times were prepared. Remarkably we received a positive reply to our request to Jean-Marie Auzende to stop off with the NAUTILE in November and try to recover OBS #55. The first seismograms were being plotted, and there were many excellent records among the hundreds of spurious triggers caused by noise bursts of one sort or another.Our engineering efforts at this point were focussed on devising practical schemes to maintain the recorder package sufficiently level to avoid levelling problems with the optical disc drive(it must be horizontal to within 15 degrees in the 'along pressure case' plane).

Thursday, 8th October brought cloudy, windy, rough weather that would have made working very difficult and tiring on the OCEANUS but which on the EWING was quite comfortable. Plans were hatched to use sugar releases (as originally described by Tim Barash for use with the MIT OBS) to delay release of the sensor package until sometime after the arrival of the instrument on the ocean floor. As we began to look at more of the data we understood that our preliminary analysis of the causes of the technical problems with the instruments was oversimplified and that indeed a number of modes of failure existed (see Appendix 7 for a summary and Appendix 6 for a detailed description).We understood that the nature of the required instrument modifications was such that a test deployment was advisable and discussions began with J-C Sempere concerning how this could be achieved with the minimum impact on his ongoing survey program.

In a few days J-C's survey plans called for us to cross the ridge and begin work on the eastern side. We decided to stop off at OBS #55 again, confirm its status and at the same time, and at approximately the same location, deploy an instrument for the test. With some disappointment, but not surprise, we learned that NAUTILE was not permitted to dive in the vicinity of glass balls so the future of OBS #55 once again became uncertain. In devising an approach to the design of a delayed release for the sensor package we began to learn more than we wanted about the solubility of sugar in salt water under pressure!

Friday and Saturday were spent continuing our assessments of the data quality and nature of the instrument failures (as detailed in Appendices 6 and 7) and refining designs for a new anchoring scheme to allow the frame to float level (see Appendix 11) and a new sensor release configuration to replace the footpad.We established a timeline of the various key steps that have to taken to prepare the OBS for redeployment. The first important target after the test deployment is the completion of all investigations and original modifications next weekend. We are determined to stick with this schedule and avoid any possibility of time pressure detracting from the quality of the instrument preparation process.

Sunday 11th October brought the worst weather so far: grey skies and 25 knot winds but we prepared OBS #54 for the test deployment tomorrow anyway in the hope that the conditions would improve. During this preparation process we found a fundamental problem with the new acquisition software - version 3.56 - and decided to stick with the same PROMS that we had used for FARA.01. At 0615 LT on Monday 12th October we hove to above OBS #55 one last time in miserable weather conditions. Nevertheless we achieved solid acoustic contact and confirmed that it was still on the seafloor and then departed leaving one of the transponders enabled. Because of the rough seas we decided to delay the test deployment until the following day. Hydrosweep crashed for an hour or so in the early evening and caused us to have to repeat a few miles of track. The problem was not serious - upon rebooting the acquisition computer all seemed to be well. It is Columbus Day today - the quincentennial.

Sunshine, calmer seas and only 15-20 knot wind speeds allowed us to proceed with the test deployment on Tuesday 13th October, OBS#54 being launched over the stern without difficulty at 1220 LT. Although the soluble releases used to deploy the arm, and the new anchor tethering arrangement were certainly jury rigs, the instrument looked in good balanced shape as it was lowered over the side.Impact with the seafloor in water depth of 3330m was observed at 1308 LT after which we departed the area to continue with the Hydrosweep survey. A detailed description of the plans and rationale for this test deployment are presented in Appendix 8. We again broke off from the Hydrosweep survey at approximately noon on 14th October and arrived on station to recover OBS # 54 at 1320 LT and sent the release command at 1330 LT. The instrument surfaced 5 minutes early in calm seas and bright dazzling sunlight. at 1452 LT. As described in Appendix 8, although the instrument was sighted on the surface immediately after receiving the first radio beacon signals, it took another 30-40 minutes to actually come alongside and retrieve the unit. Inspection of the levelling indicators brought excellent news - it seemed everything had worked as planned. Later analyses of the data confirmed these early impressions (see Appendix 8) The first of the soluble releases activated after approximately 1 hour 50 minutes in the water.

Following recovery of this OBS we got underway again at approximately 1545 LT and continued with the survey lines to the east of the ridge.

Morale was greatly improved over the next few days as it became more and more obvious that the test deployment had produced excellent results and gave us good solutions to many of the problems that had plagued us on the FARA 01 deployment.We sent in our first 'formal' status report to our colleagues ashore on Thursday 15th October and continued the tedious process of examining sections of data from all the instruments and identifying and documenting every type of failure we could find (Appendix 6). A valve failure in the engine room contaminated the ships freshwater supply with salt water so the coffee tasted unusual for a while! This was fixed in a day or so. On Friday plans were started on how we planned to carry out the data reduction, as our pseudo-random quick-looks at selected sections of the data began to yield fewer and fewer new insights, and mass production of the soluble releases and anchor components began. In searching for the hardware required for these changes it became increasingly necessary to rob Jim Broda's van of more and more components, even down to stripping out the electrical conduit tubing and leaving cables hanging on the walls! Evaluations of both the data from FARA 01 and the test deployment were confirming that the microseism peak is a significant cause of false triggers especially on the hydrophone channel and ideas were considered for protecting against this. Saturday and Sunday were spent finalizing decisions that defined the electronic modifications that would be carried out on the instruments (Appendix 6), and a plan and timeline was devised for the orderly preparation of all the OBS for deployment. The key target date is to begin the 30 hour long 100MB full system tests on all the instruments late on Tuesday, or at the latest , first thing on Wednesday morning. Saturday was a landmark day because John Hallinan devised an explanation for the spikes that had been observed on some of the data - he showed that when one of the seismometer sensors is tilted sufficiently to be against its stops, then the grounding of the OBS is changed in a way that causes the A/D to generate spurious spikes. Despite the mistreatment that many of the sensor packages must have suffered during their deployment and subsequent recovery from the seafloor, an inspection of the interior of every package showed no visible mechanical damage had been incurred. This inspection process was expensive in human terms - both Beecher Wooding and John Bailey strained their backs lifting these ungainly spherical pressure cases in and out of the lab.

Sunday 18th October was a beautiful calm sunny day. For the first time we held a barbecue although with the clocks only one hour from east coast time it was dark before everyone had finished eating! In consultation with J-C a plan was devised for the timing of the remainder of the cruise - this involved beginning the OBS deployments at 0600 on November 1st. We decided that to beat the false triggers on the hydrophone channel generated by the microseisms, we should modify the hydrophone preamplifiers to substantially attenuate energy below 5 Hz. The search for the electronic components necessary to do this began. Beecher Wooding and John Bailey devised a scheme to electrically insulate the seismometer sensors from the remainder of the sensor package and tests showed that this solved the spike problem. This means that even if we do have sensor packages fall on their side in the forthcoming deployment, because of extreme small scale seafloor topography, we still will be able to collect high quality data on the hydrophone channel.

Monday 19th October brought 30 knot winds and rough confused seas - we experienced some of the first reasonable rolls of the trip! Little did we know how long this rough weather would last. The focus of the effort through Tuesday 20th was the design changes to the hydrophone preamplifiers that would effectively attenuate the microseism energy down near 5 seconds period. In investigating this John Hallinan came up with a new approach to the grounding of the preamp that seemed to remove intermittent spikes that were observed under certain combinations of circumstances. But some problems still remained at the end of the day. Data analysis efforts yielded some cheery news in the form of a histogram of numbers of events that were recorded by four or more OBS: it showed that an average of approximately twenty events per day fell into this category over about a forty day long period. So if even half of these are locatable we will have a substantial data set. Hope still existed that we would be able to persuade the NAUTILE group to dive on OBS #55, if we only requested that they inspect visually, without touching, to document the reason for the failure. Contact was again made with Maurice Tivey in Woods Hole, who would be participating in that cruise, to determine whether he had any additional information or insights.

On Wednesday 21st. October we put aside the problems with the preamplifiers (after faxing the modified circuit diagram to the gurus at WHOI for their review and comment), and began setting up for the big 100 Mb test of all the OBS. The intention was to record 100 Mb of 'data' (10Hz sine wave from a function generator) on every instrument. This would take about 26.5 hours, once every OBS is set up and recording. All the OBS were ready to go by early afternoon and the process of programming each instrument, and going through the usual 'pre-launch' check procedures began at about 1500 LT. By 2030LT we had 12 OBS recording and had found two failed units. In attempting to find the cause of failure on these two instruments two other OBS were inadvertently powered down so we decided to carry out a second separate test on the following day of these four units. The test set-up that allowed us to run all 14 OBS simultaneously had two flaws. The function generator signal was connected to the acquisition packages in an extremely tenuous manner - connectors were not used. Individual leads were attached to the separate pins of each acquisition package. Secondly, we were restricted in the kind of program we could run for the test because the power supplies could only reliably operate 2-4 Maxtor recorders simultaneously. So we tried to uniformly distribute the predicted turn-on times of the Maxtors. This was only really possible in continuous record mode. So that was the test: just a single 26.5 hour long continuous recording session. The first outline plan for how we would carry out the data reduction of the FARA 01 results was formulated and steps were taken to implement the Matlab based system. A last plea to Jean-Marie Auzende to dive with NAUTILE on OBS #55 was sent by fax and email to Brest.

The weather continued to be disagreeable through Thursday 22nd October. The wind was 30-35 knots generating 15-20 foot waves that on some courses reduced our speed down to 6 knots.Hydrosweep was having trouble with the extreme motion losing perhaps 20% of its beams.The TV set in the lounge took a dive off its shelf overnight. Apparently it had not been secured! The two defective OBS had been fixed so before lunch they were prepared and started on their 100Mb tests. We received a reply from Ken Peal at WHOI approving our plan for the modification of the hydrophone pre-amps. The first of the OBS completed their 100 Mb test run at 2030 LT so the process of debriefing and removal of the discs began . The units were in their pressure cases in the Wet Staging area and sufficient water was being taken on the fantail that an inch or two was sloshing around on the deck in that lab. This was impossible to prevent given the nature of the seal beneath the large aft-facing overhead door. It was decided to keep the water tight doors at the aft end of the Dry

Staging area closed overnight because we were occasionally taking sizable seas on the fantail.

Friday, 23rd October was yet another day of high seas and bad weather and was spent analyzing the results of the 100Mb tests. This analysis effort was made difficult because the primary failures observed in the data were almost all relatable to the test set-up.There were three primary characteristics: on some of the units the sine wave ceased to be recorded on all four channels: correlation of the time at which this occurred showed that it was at exactly the same instant on all the instruments. Therefore we concluded it was due to a disconnection of the function generator leads. On several units optical disc recorder errors occurred that were accompanied by sets of empty data blocks that varied in duration from a few up to over one hundred minutes(see Appendix 6). Correlation of the times at which these events occurred showed that they were at times at which multiple recorders were simultaneously powered up.Because it was known that the power supplies were incapable of maintaining more than a couple of Maxtors operating at the same time, again the conclusion was that this was not an indication of instrument failure. Thirdly, there existed throughout the data pseudo-random glitches of almost identical character on all the units. Correlation of time across OBS's again convinced us that these noise spikes were somehow generated outside the OBS system. These tests did however reveal a couple of minor failures in two OBS and did well establish the operational state of the majority of the units.

However, by far the most significant event of the day was the receipt of an email from Jean-Marie Auzende announcing the fact that they would be willing to dive on OBS#55!! No commitment to attempt to recover the instrument was made - but the NAUTILE team did agree to go down and try to determine the cause for failure. This was great news. A meeting of NAUTILE's safety commission was to be held on November 5th to set the ground rules concerning whether or not, and under what circumstances, the submersible could interact physically with the OBS.

The following day brought the first signs of improved weather conditions. Concerns about how to modify the hydrophone preamplifiers to attenuate the microseism energy dominated the engineering effort and data reduction remained focussed on the analysis of the 100Mb test data. By the late evening the decision had been made to substantially reduce the magnitude of the planned preamp modifications. The intention now was to change only the capacitor that couples the preamp to the notch filter in the acquisition package to such a value that the corner frequency is shifted up to approximately 10 Hz, and so attenuate 5 second energy by an additional 18-20 dB. This was less than we had hoped. but simulations of the effects of this change on OBS data collected during FARA 01 showed encouraging results. The next day, Sunday 25th October, was calm and sunny - the first good day in a long time.But progress in the lab did not match the climate change. In devising a test procedure to check the preamps after they had been modified, an inconsistency was identified between the results obtained and those recorded the previous day during the initial development of the modification. All morning was spent tracking down and understanding this inconsistency that was eventually explained by a non-linearity in the response of the anti-aliassing filter board. Once this had been understood and we were confident that the preamp modification was not detracting from the OBS performance then John Bailey began routine modification and testing of all the hydrophone preamps. Analysis of the 100 Mb test results progressed to a stage when units could be released for routine pre-deployment preparation. By the end of the day four OBS frames had been fully modified with their new anchor rigs and were ready for loading. It was a barbecue day but it was dark before it was over!

Hydrophone preamp modifications continued through Monday 26th October, that was a calm pleasant day. The engineers finished the welding of all the eyes onto the modified anchors for us and checks of the OBS cables revealed a fatal cut in one hydrophone lead and a broken conductor in one of the sensor cables. Analysis of the results of the 100Mb test data set continue - this was a significant project in itself! But this was essentially finished by the end of the day and a systematic plan was devised for the routine preparation of the OBS on the following day.

Occasional rain squalls intruded into an otherwise calm day on Tuesday that was spent in full time preparation of the electronics. By the middle of the afternoon, all but one set of electronics had been released for preparation and loading. Eight pairs of acquisition and recorder packages were ready to be loaded on their frames by 2200.

Immediately after breakfast on Wednesday 28th October we began loading the available eight pairs of acquisition and recorder packages onto their respective frames. Because of the calm weather we were able to open the large overhead door on the aft end of the Wet Staging Area. This provided direct and easy access to the fantail with a hand trolley so that by 11 am we had all eight OBS loaded. The afternoon and evening of Wednesday was spent preparing the last six pairs of electronics. This was complete by the middle of the evening.And on the following day they were loaded onto their frames on the fantail. Again the weather remained good so the operation was straightforward. By the end of the day all fourteen OBS were operating on the fantail, on the sail loop, and the final phases of the pre-deployment procedures could begin. After much agonizing the design of the network was finalized as was the nature of the acquisition program for this second deployment (see Appendix 12). It was decided to record the airgun shots in continuous record mode because the repetition rate of 45 seconds would result in very little benefit to an event detect mode of operation.. Then the majority of the deployment was with the hydrophone sensor as the event detector, with the threshold short-term average(STA) to long-term average(LTA) ratio being 3. Approximately ten days were to be spent with the vertical seismometer detecting events but in this case the threshold STA/LTA would be substantially greater - 7. Inspection of the data from FARA 01 had shown how dominant the shear wave energy was on all the seismometer records, frequently with amplitudes five times greater than the compressional wave arrivals.

Friday, 30th October was another calm sunny day. All the OBS are on the fantail hooked up to the sail loop. One bad seismometer channel has been found, the clocks need to be set and the final pre-deployment checks and programming completed. The bad seismometer was fixed (a dead chip *and* a broken wire inside the sensor package) and the formal programming procedure was begun in the late afternoon. Consideration had been given to attempts to synchronize the four hour periods over which the OBS counted events for the lock-out decisions, but this was found not to be simple and would require significant change to the normal pre-deployment procedures. Eight OBS were fully programmed, unplugged and ready to be launched at 2100LT. J-C's Hydrosweep survey was completed at midnight and course was set to the north-east to the site of the OBS deployment on the ridge near latitude 35N. The last six OBS were programmed and ready to be launched by mid-morning of Saturday 31st October. The weather remained good and we hoped it would hold for another 24-48 hours. So on Halloween night we all went to bed early to be ready for the big deployment day that began at 6am the next morning. Unfortunately we did not get off to a smooth start - the first instrument gave us inexplicable problems with its air acoustics check, even though it had performed flawlessly in the same test only two days previously. This caused a one hour delay in the first deployment: we decided to skip over OBS #54 and begin deploying the remainder modifying the deployment order to enable us to easily deploy 54 later in the day should we be successful in locating and fixing the problem with the acoustic release. The times and positions for these deployments are listed in Appendix 3 and illustrated in Figure 3. We were indeed successful in fixing the problem with 54 although not in a very satisfying manner. The offending release was removed from the frame, de-tubed in the lab, voltages verified and a visual check carried out. Acoustic tests in the lab gave good results and it also performed well following reassembly It was replaced on the frame, checked one more time and then launched. By afternoon, despite the fact that the weather was not as calm as we would have liked, progress began to speed up as a good routine was established and the deck team began to 'get ahead' of the ship. The one cause of frequent delays was the air acoustics test that occasionally was simple and sometimes was slow depending on the nature of the noise environment in which a particular instrument was sited. Nevertheless, because progress was good and the weather seemed to be steadily worsening the decision was made in the mid-afternoon to deploy all the OBS in this one session, instead of breaking off for the night after launching ten or so.The last OBS was launched at around 2000LT substantially ahead of schedule. The last few instruments had been deployed at a rate of one every 45 minutes! All were positioned within a few hundredths of a mile of their intended sites. Launching the units over the stern under the A frame using the fantail crane worked well.

Immediately the fantail was secured following the cessation of deployment operations, we got underway to carry out a Hydrosweep bathymetry survey of the network site. At approximately 2030LT 1st November we got underway at full speed, the magnetometer was launched and we began steaming through the 44 way points that defined this small survey.The only negative occurrence that detracted from an otherwise excellent day of considerable achievement, was the demise of our SUN workstation: INDIGO. The extent and nature of the problem with this computer was not immediately obvious but our data processing efforts were temporarily brought to a halt.

The morning of the 2nd. November brought 25 knot winds and uncomfortable seas but the Hydrosweep survey was progressing well and was exactly on schedule. In fact we were able to add a short piece of track to a small gap in coverage created by the shallow water depths over the crestal mountains and still were in plenty of time to begin airgun launching operations at 1600 LT. This was to give us two hours to get the system firing reliably before the OBS's started recording at 1800 LT (2100Z). As it happened, we needed this time. Only one of the two guns fired reliably and it was not until a little after 1900 LT that both guns were firing on their 45 second repetition rate. The seas were considerable by this time and the varying ships speed caused the gun depths to vary substantially between 40 and 100 feet.. The guns operated for 22 hours without a problem. The logging of the shot times and navigation, and the gun synchronization proceeded faultlessly. It was intended to run the airgun lines until 1800 LT
3 rd November, but by 1700LT the weather was sufficiently bad that the Captain requested that we terminate the shooting early to reduce the risks associated with the recovery of the heavy guns on the heaving and very wet fantail.Immediately following this trouble-free recovery course was set for Bermuda although the maximum speed that could be maintained at that time was less than 9 knots.

Investigations of the cause for failure in INDIGO revealed that the problem was in the 1.2 GB hard disc drive: without this drive the computer was successfully rebooted, but all the arrival time picks of water waves that had been made over the last 2-3 days were lost. The tedious process of making all these picks would have to be repeated. Messages were sent ashore to determine what cause of action to take with attempting to repair /replace/recover this hard disc.
Attempts to begin packing our equipment away in our shipping van on B deck got off to a good start on the 3rd but were quickly curtailed when the small crane burst a hydraulic line.Following this for the next few days we could only move boxes into the van by hand.

On passage to Bermuda we began processing the Hydrosweep data that we had collected over the network site and depended for instruction and help for this upon colleagues J-C Sempere and Anne Briais, both of whom could not have been more helpful and co-operative. Slightly improved weather conditions on Thursday 5th November allowed us to maintain a ships speed over 10 knots for the first time, but the seas remained rough and packing activities were hampered. But by Friday the weather was improved. Light winds and calm seas brought speeds over 12 knots and an assured on time arrival in Bermuda.

We arrived in St Georges on schedule at 8am on the 9th November. The cruise report had been completed, the Hydrosweep data were processed (to some level) and we had looked at the OBS results from FARA 01 sufficiently to know we had recorded an important and valuable data set.

PRELIMINARY ASSESSMENT OF FARA.01 RESULTS

Activity levels and Event Counts

An overall total of 40076 triggers occurred while the instruments were in event-detect mode (Julian day 235 to 276). Each instrument triggered independently, and reasons for the triggers included shots, codas, earthquakes, microseisms, electronic and biological noise.On average, about 1000 triggers per day occurred across the network (Figure 4). A sharp increase in this rate coincided with the shot-firing that occurred between days 235 to 237. The change from triggering on the hydrophone channel to triggering on the vertical channel on day 260 registered as an increased rate of about 1200 triggers per day. As the triggering threshold did not change, this increase was due to the vertical seismometer being more sensitive to S-waves than the hydrophone to P-waves, for small events.

The broad peak centered on day 242 in Figure 4 was probably due to an increase in the level of microseism noise. This long-period (c. 5s period) noise caused many false triggers on the hydrophone channel (see Figure 5 for an extreme example). That this was indeed due to microseism noise and not a temporal increase in earthquake activity was confirmed by removing from Figure 4 the triggers common to less than four instruments. In this case (Figure 6) the peak disappeared.

The behaviour of individual instruments during the event-detect period is summarized in Figure 7. The changeover from hydrophone to vertical triggering caused an increase in the triggering rate of all properly working instruments, except for 64 and 51 which had faulty (tilted) seismometers.

'Lockout' is the term we use to refer to the software control in the OBS that is designed to ensure that we record data distributed throughout the deployment period of the instruments. For this deployment. the data acquisition software would not permit the instrument to trigger more than 35 times in any four hour period. and comparison with the gradient of constant-lockout in Figure 7 shows that most of the working instruments were continually locking-out. This was especially so during the vertical triggering (after day 260), during the shooting (day 235 to 237) and during the peak in microseism noise (day 240 to 245).

Many shots were missed by some instruments because they locked out so much. Each shot triggered up to six successive codas and this, superimposed on the high rate of 'natural' triggering, shortened the time available for recording before the instrument locked out (Figure 8). This problem varied with instrument. OBS 61, for example recorded only 30 out of 72 shots while OBS 63 missed none. The shot capture data are summarized in Appendix 13.

Inspection of the data from selected days and instruments revealed that most of the triggers were caused by small but real seismic events. OBS 54 triggered on at least 90 real events out of 130 on day 237; on day 267 earthquakes were the cause of more than 80% of the triggers on instruments 54, 59, 61 and 63. The other triggers were caused by noise bursts, electronic spikes and microseisms.

In Figure 7 there is a short decrease in the gradient of several of the lines just after day 270. Given that most of the triggers were due to small earthquakes, and that the instruments operated independently, this decrease probably reflects a real reduction in the level of seismicity.

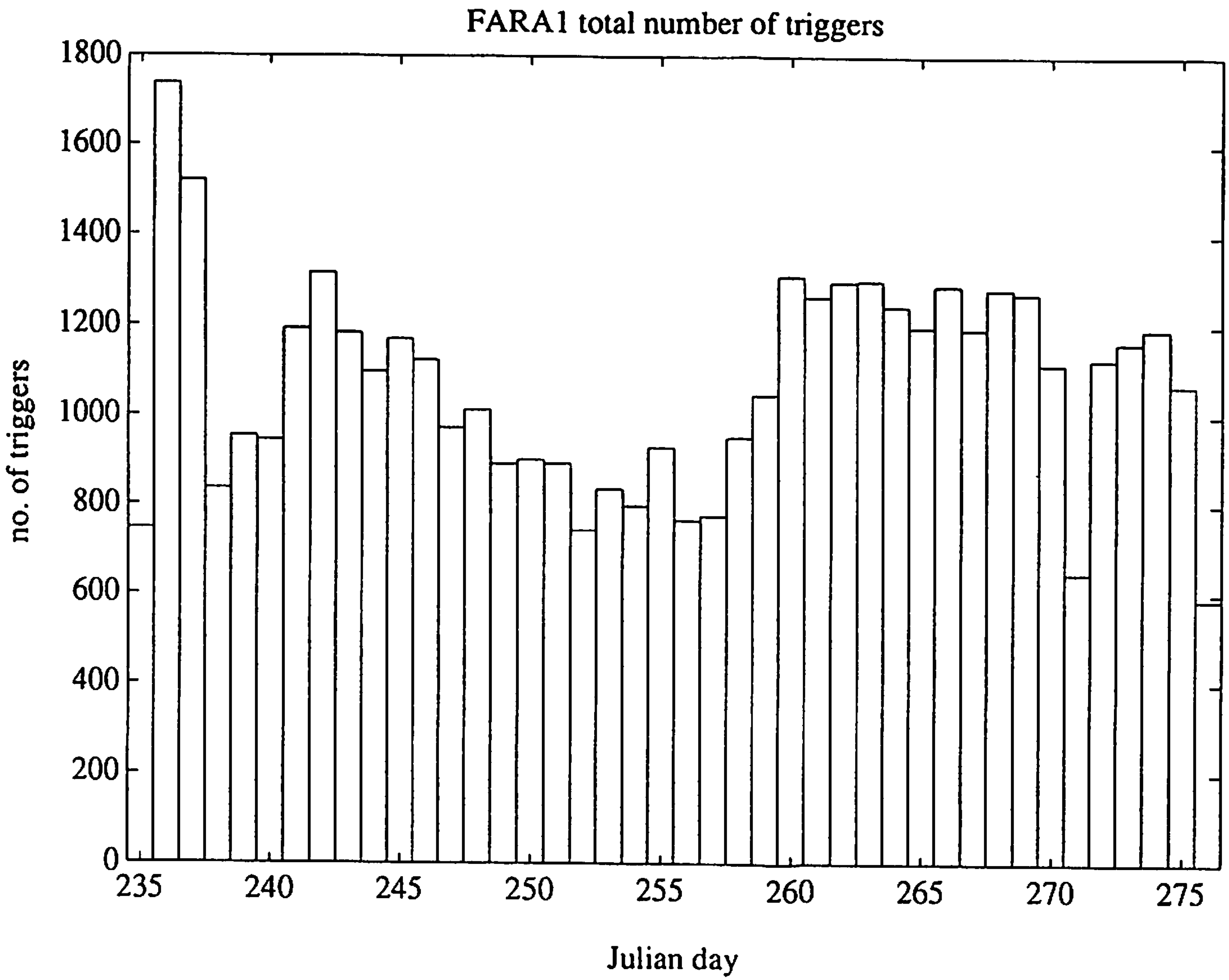


FIGURE 4 Total number of event triggers recorded by the FARA 01 network. OBS locations for the FARA 01 network are shown in Appendix 13.

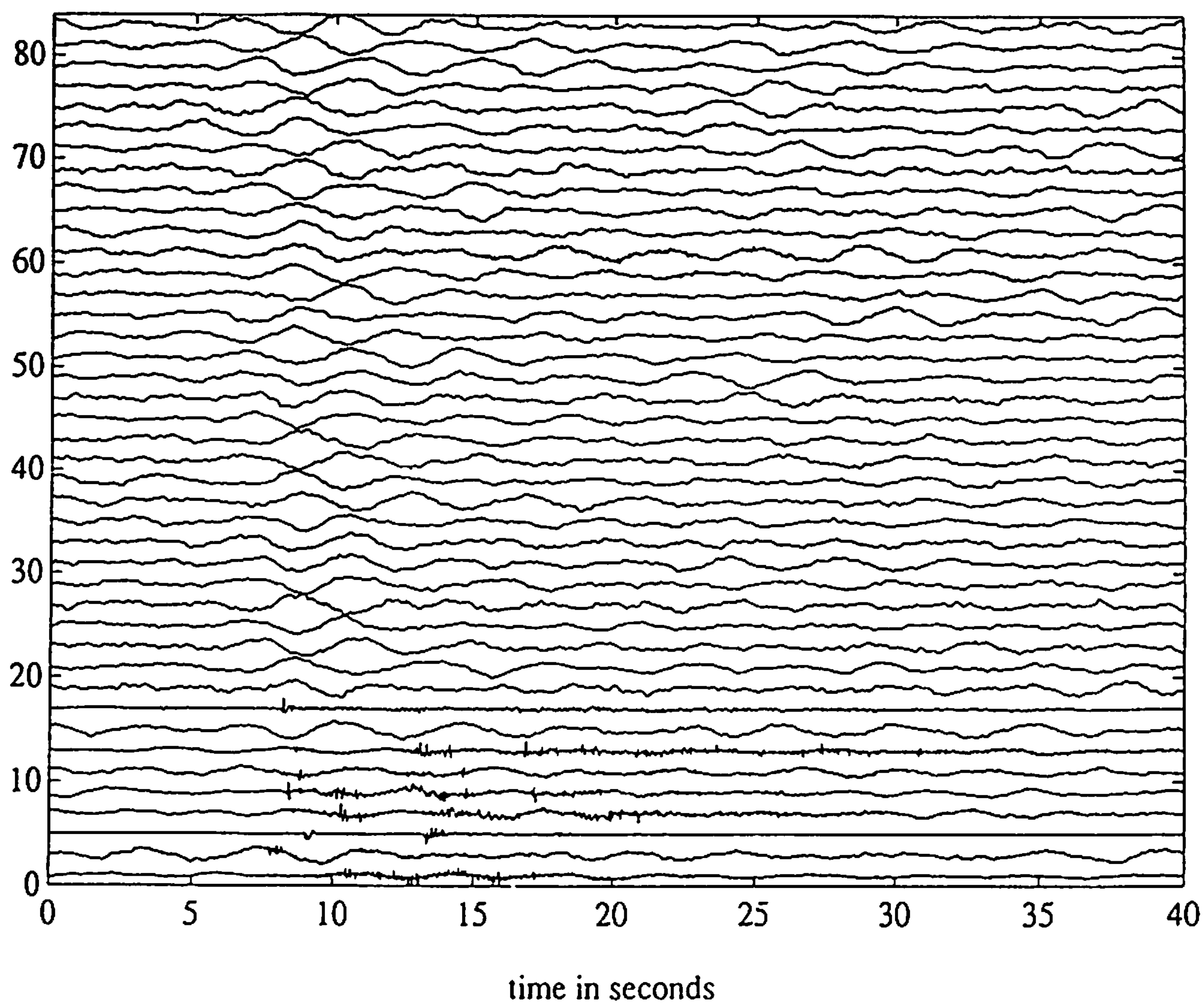


FIGURE 5 Shown above are the complete event records (each 40 secs long) for the first fifty events recorded by the hydrophone on OBS #54 on day 242. The triggering window is between 9 and 10 seconds. The figure illustrates an extreme case of false triggers on bursts of long period microseism noise.

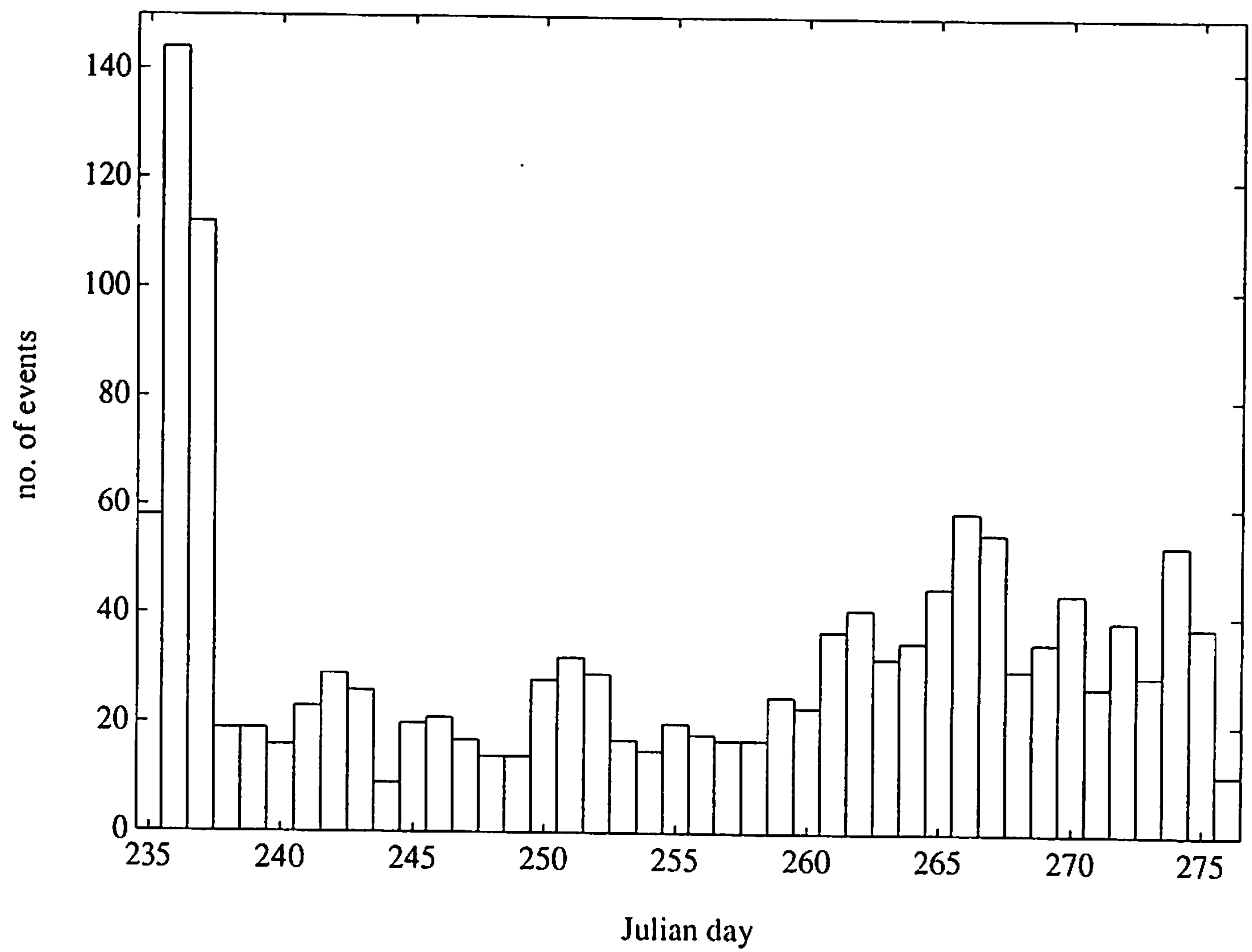


FIGURE 6 A histogram that shows the number of events per day that triggered four or more OBS instruments within 10 secs of the same instant in time.

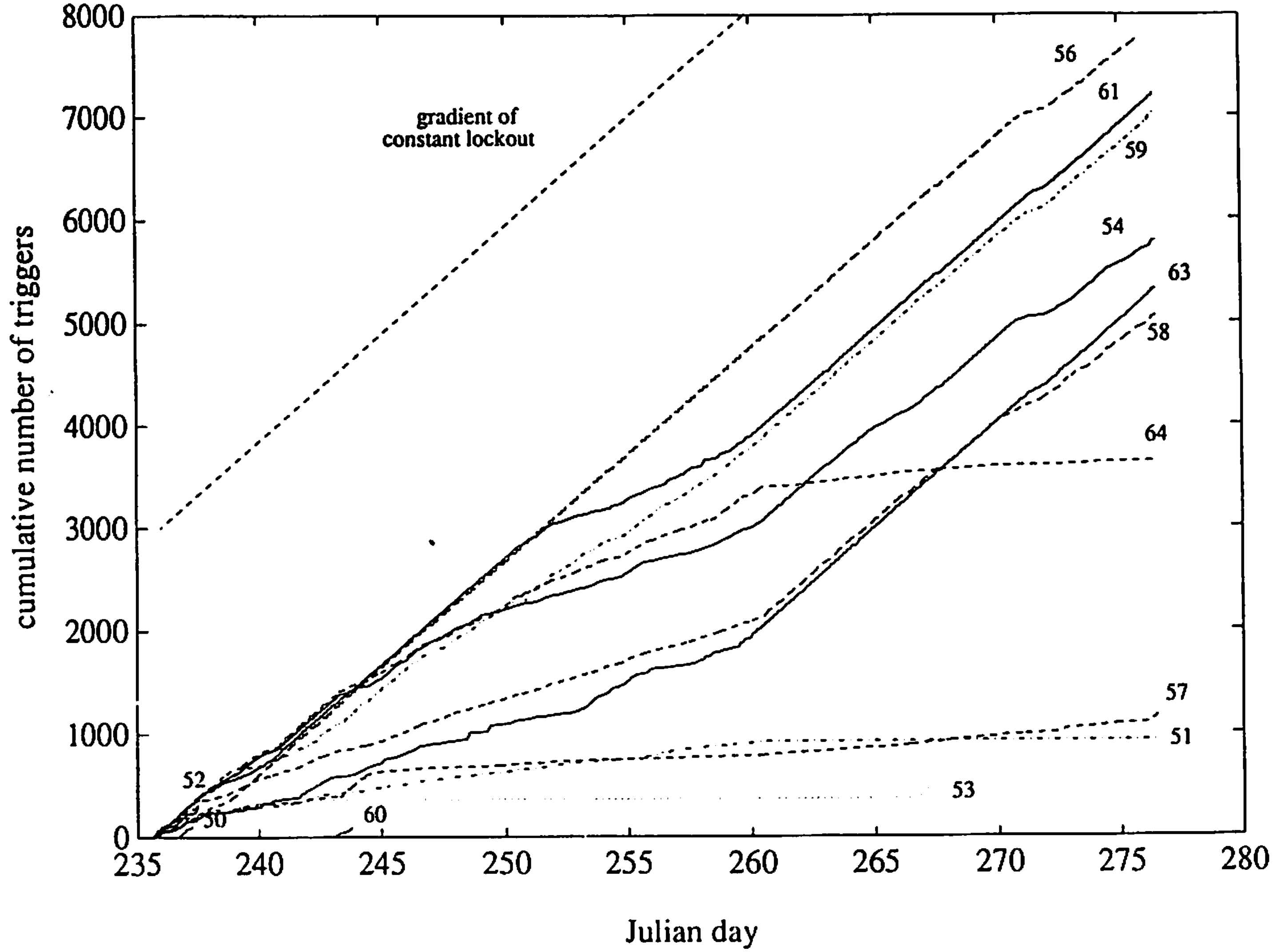


FIGURE 7 A plot of the cumulative number of triggers on each OBS versus Julian day during the entirety of the event detect period of FARA 01. The gradient corresponding to the instrument lockout of 35 events per 4 hours is shown for comparison.

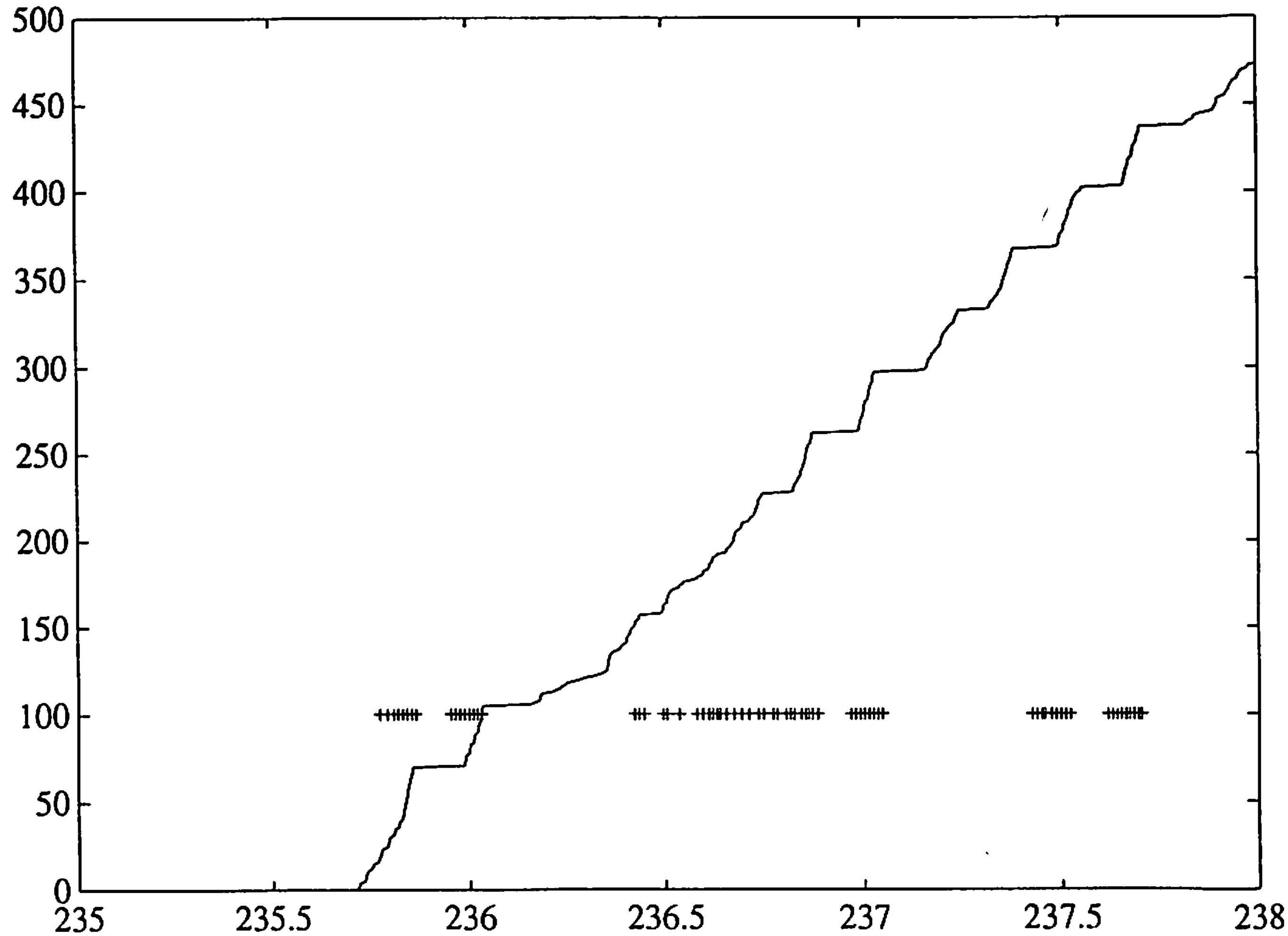


FIGURE 8 A plot of cumulative number of triggers on OBS #54 during the period in which the explosive shooting was carried out. The times of the shots are marked by the crosses. When the gradient of the line is zero the instrument is locked out. It can be seen that many shots fall within locked out periods.

Triggers which occurred on several instruments at approximately the same time were identified in order to isolate real and useful earthquakes (recorded on four or more instruments) from false triggers and very small events.The first sample times of every trigger (contained in the event *.ef header files produced by obsed.c - see Appendix 15) and from all instruments were collected together and grouped with other times which fell within a 10s window. These groups were then organised according to the number of triggers they contained. Ideally each group would have contained all the trigger times for a single earthquake. Applying this method to identify the shots, however, revealed that some triggers were not included where they should have been. The high level of natural activity often caused instruments to trigger several tens of seconds before the shot instant, and although the shot was recorded later in the 40s record, its trigger time was not grouped with the other triggers from that shot. This was a minor problem, easily solved by inspection of the other trigger times.

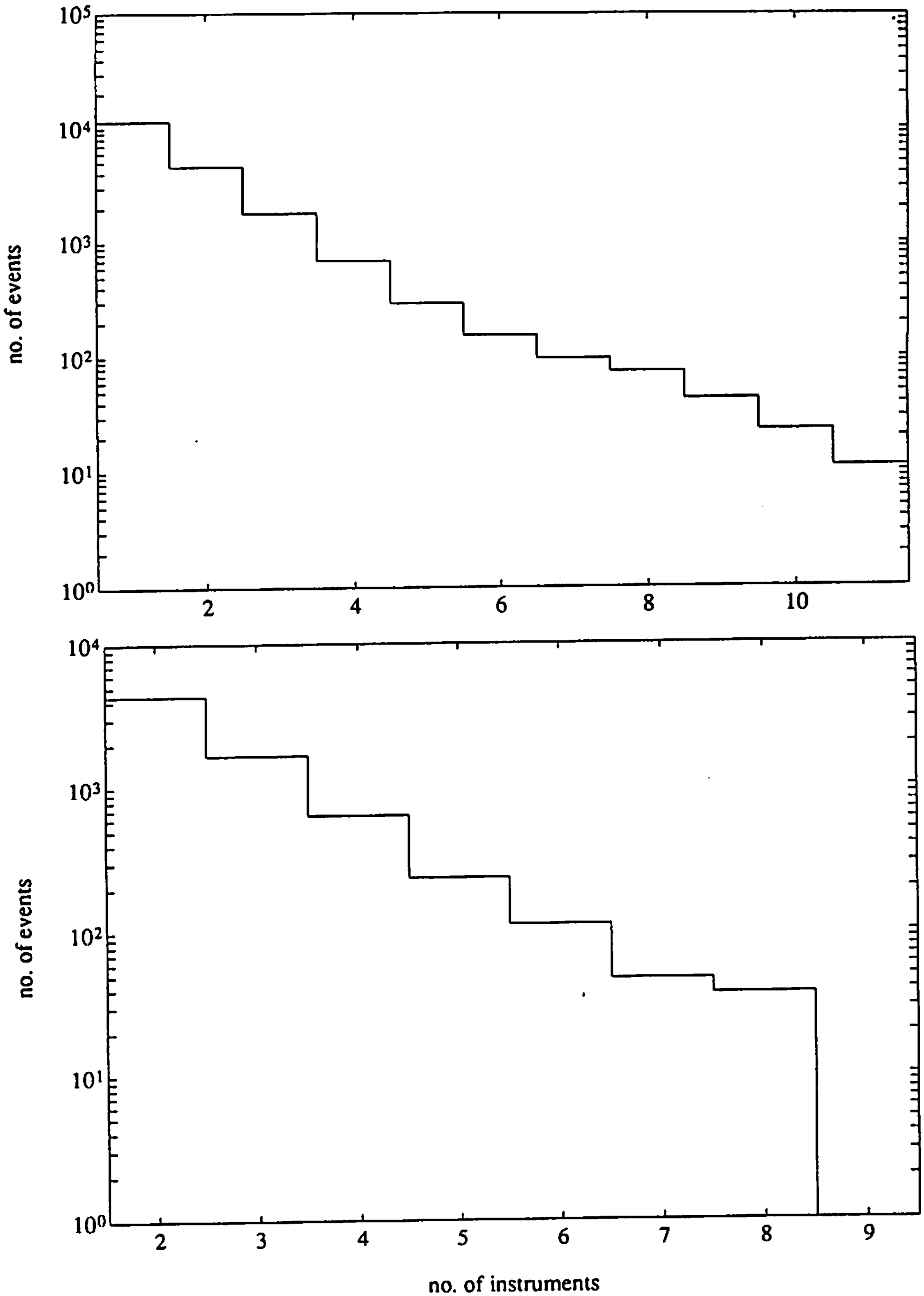
By assuming that events which triggered on four or more instruments were real earthquakes, a more accurate analysis of the levels of useable seismicity is possible. In Figure 9 the number of events by number of instruments is plotted; (a) includes the shots while (b) excludes data from the shooting days. About 200 events triggered six or more instruments; over 1000 events triggered our or more OBSs.

A look at the numbers of events recorded on four or more instruments every day (Figure 6) reveals that about 20 events per day were recorded during the hydrophone triggering and about 35 per day during the vertical triggering. Comparison with Figure 4 shows that the shots are still visible but that the peak caused by higher microseism activity is gone. The shorter-wavelength peaks on Figure 6, at days 250, 242 and 265 may be significant as either increased seismicity or increased microseism levels although this is impossible to confirm without more investigation.

Figures 6 and 9 represent an optimistic view of the numbers of events which were well recorded. Larger events and shots have codas which are included in the Figures, and falsely raise the numbers of events. By how much requires more detailed inspection of the data, although this seems to have exaggerated the number of shots more than the number of earthquakes. Many of the shots had multiple coda triggers, although from the study of day 267 only two natural events were large enough to cause more than one trigger.

Another assumption made in the figures is that each trigger relates to a seismogram of sufficient quality to be picked. Faulty sensors and recording equipment, small events, emergent events, and noise could all compromise this ideal ,and so reduce the number of locatable events.

Inspection of seismograms of common events during days 246 and 253, shows that about 20% of the events can be picked and are potentially locatable. This very subjective analysis suggests that perhaps 100-200 of the events recorded during the event detect period will be locatable.



FIGURES 9a & 9b Plots of number of events against the number of receiving instruments that triggered within a 10 second window. The uppermost plot (a) is for the period days 235 to 276.The lowermost plot (b) is for the time period days 238 to 276 (i.e. as (a) but excluding the days on which explosive shooting occurred).

Some Event Characteristics

Preliminary studies of the OBS event-detect data reveal eight different classes of events:
shots, codas, microearthquakes, distant events, small microearthquakes, microseisms, non-seismic events (biological) and electronic noise generated by the instrument.

Shots Twenty-six 6lb and forty-six 60lb explosive charges were detonated during days 235 to 237, immediately after deployment (see Appendix 13 for the shot table, and the FARA01 cruise report for details on the shooting). The shots were generally well-recorded except when 'lock-out' caused a problem (see previous section) or when an individual instrument failed.They were characterised by very high amplitudes (on the order of 10^7 Collins units), especially on the hydrophone channel. A typical shot record is shown in Figure A9.11. Other characteristics included strong water-column reverberations and impulsive first arrivals although these became less impulsive with increasing range. Most of the shots generated coda that caused up to seven triggers.

Codas Repeated triggers on the codas of large events and shots occurred because the event detection algorithm did not reset the long term average after each trigger. The large amplitudes of the codas were compared to the signal level before the first trigger and so their STA/LTA ratios were still high enough to trigger the instrument. These codas were identified by their first sample times (multiples of about 40s after a large event or shot), and by seismograms with large but slowly decreasing amplitudes. In many cases water column reverberations were visible above the coda level, and in some cases small earthquakes were superimposed on the coda- a coincidental feature due to the large levels of local seismicity. About one or two earthquakes per day were sufficiently large to cause multiple triggers.

Microearthquakes The definition of a good microearthquake is one that is sufficiently large to produce four or more clear and impulsive P- and S-wave arrivals on four or more stations (e.g. Figure 10). A study of day 253 revealed that up to 20% of the events identified as being recorded on four or more instruments were good microearthquakes. The average maximum amplitudes of such events were 10^5 to 10^6 Collins units. Faulty channels on individual instruments and the proximity of the earthquakes to the network meant that the quality of these seismograms varied from OBS to OBS. Several more examples of good microearthquake records are shown in Appendix 9.

Distant events A few of the earthquakes recorded were of good quality and with maximum amplitudes similar to those for the good microearthquakes, but had emergent P-wave arrivals and longer P-S times . These were classed as distant events, occurring several tens of kilometers outside the network perhaps within the Atlantis fracture zone to the north.

Small microearthquakes By far the most frequent cause of triggering and lockout was small microearthquakes. Many of these were too small to be detected by more than one instrument, and had maximum amplitudes ranging from just above noise level to about 10^4 Collins units. More small events were recorded during vertical trigger mode than during the hydrophone triggering, because the vertical seismometer was more sensitive to the S-waves that in general had amplitudes three to four times greater than the first arriving P energy.. As a rough estimate, about 200 of these small events triggered each instrument daily, with some seismograms showing more than one event in 40s. As these seismograms did not have pickable P- and S- phases and were recorded on very few instruments, these small microearthquakes will not be locatable. Figure 11 shows a seismogram from a typical small event.

Microseisms Pressure variations at the seabed caused by non-linear interactions between sea surface swells led to many false triggers, especially during the phase in which the hydrophone was being used to declare the events. This long-period (about 5s) microseism noise triggered the instrument at a positive or negative peak. Microseism activity is increased after storms (Figure 11), and this may have been the cause of some peaks in the daily number of triggers (Figure 4). The test deployment (Figure 5) was especially plagued by false microseism triggering.

Biological noise In a few cases, triggers with natural, non-seismic causes occurred. A typical record of this type (Figure A6.8), shows a transient, monotonic pulse, registering exclusively on the seismometers.

Electronic noise Some of the triggers were caused by noise generated by the OBS electronics. The worst of these problems were restricted to individual instruments, although spikes were observed on all instruments at one time or another. The STA/LTA triggering algorithm has no mechanism for disregarding spikes, although averaging over 1s for the STA limits the false triggering to larger spikes. Another pervasive electronic feature was the Maxtor turn-on, when data were written to the optical disk. This happened about once every 4MB or every 90 events, lasted for just over 2 minutes and had a distinctive signature (Figure A6.15). A third cause of false triggers, the 1-3 second-long data segments with incorrect gain information in their headers, were also seen to cause false triggers in a few cases (Figure A6.5).

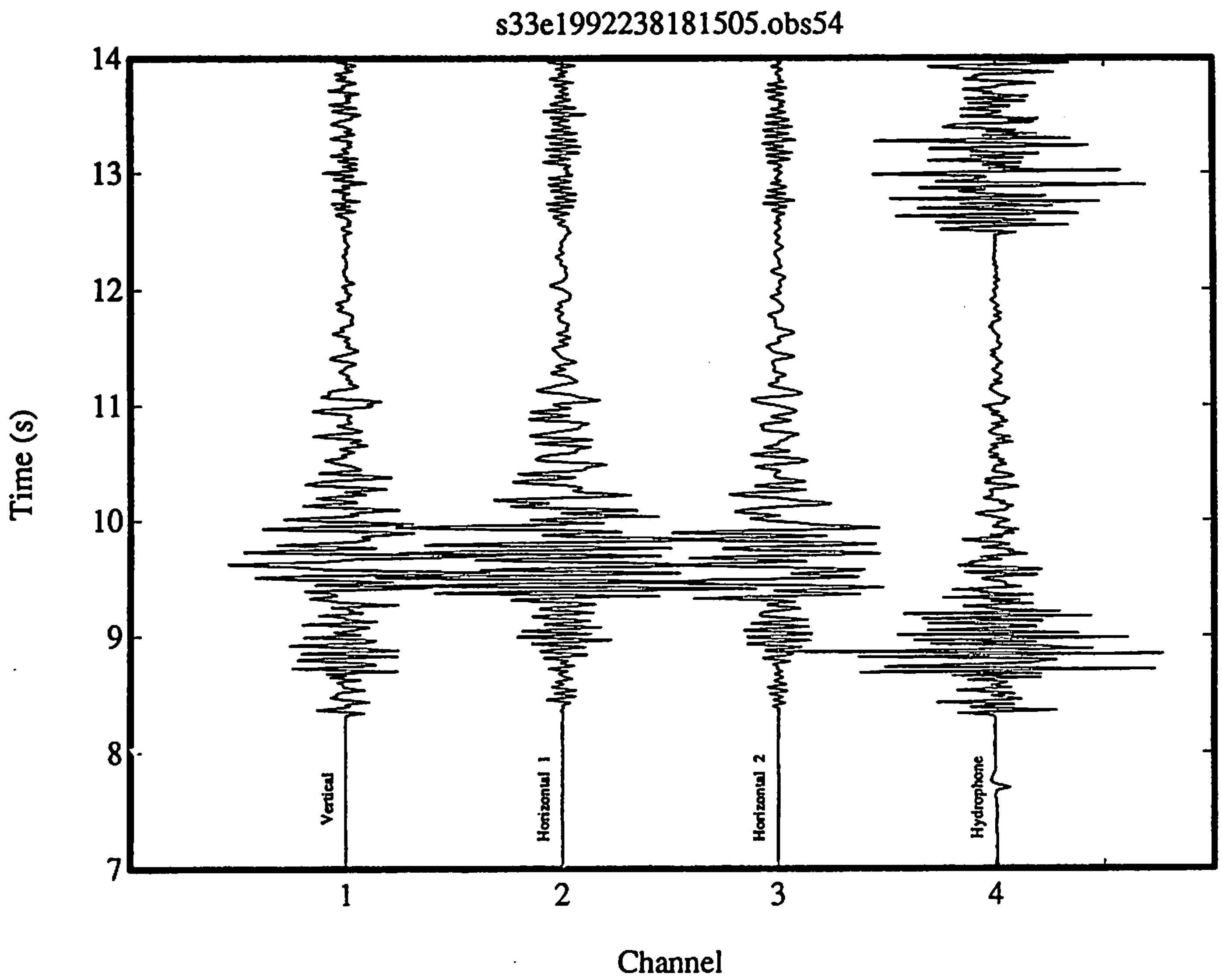


FIGURE A9.4 OBS#54 A nearby microearthquake event with a P-S time of approximately 1 second and clear first breaks on all four channels.

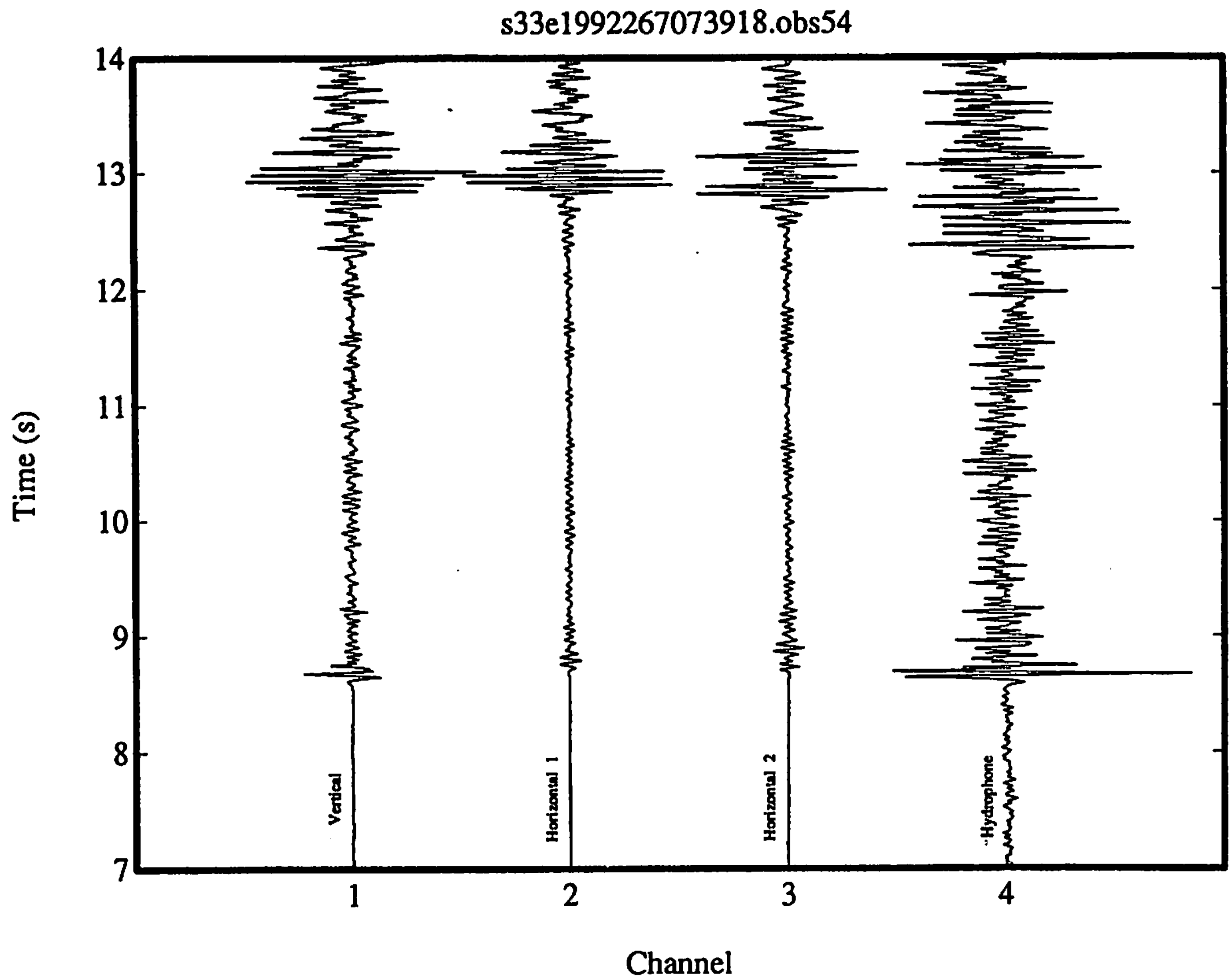


FIGURE A9.5 OBS#54 A distant event with a P-S time of more than 4 seconds but still with clear impulsive first onsets on the hydrophone and vertical channels.

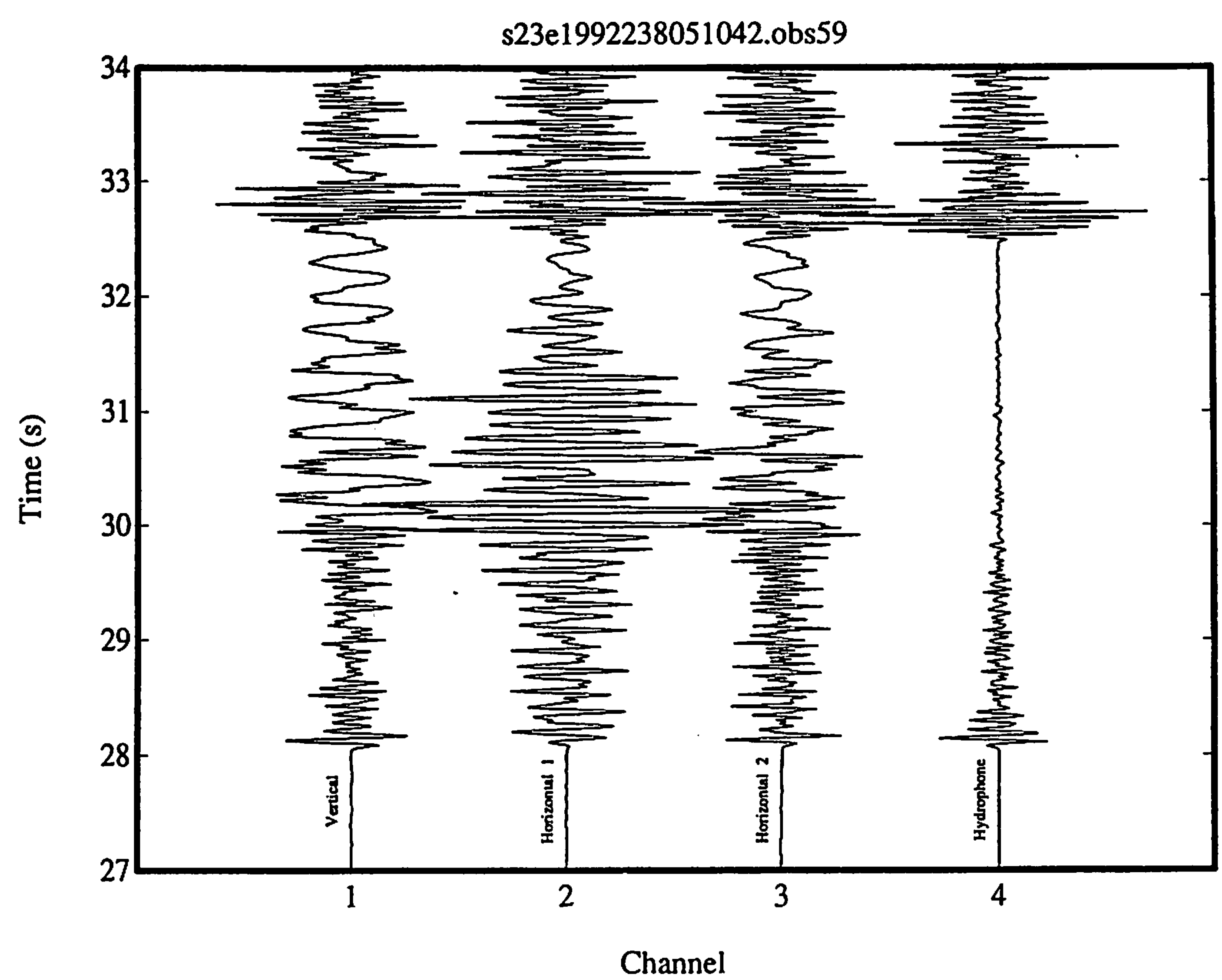


FIGURE A9.6 OBS#59 An example of an event without such a clear S wave arrival as that observed on previous records presented here. The water column multiple is clearly observed on all four channels.

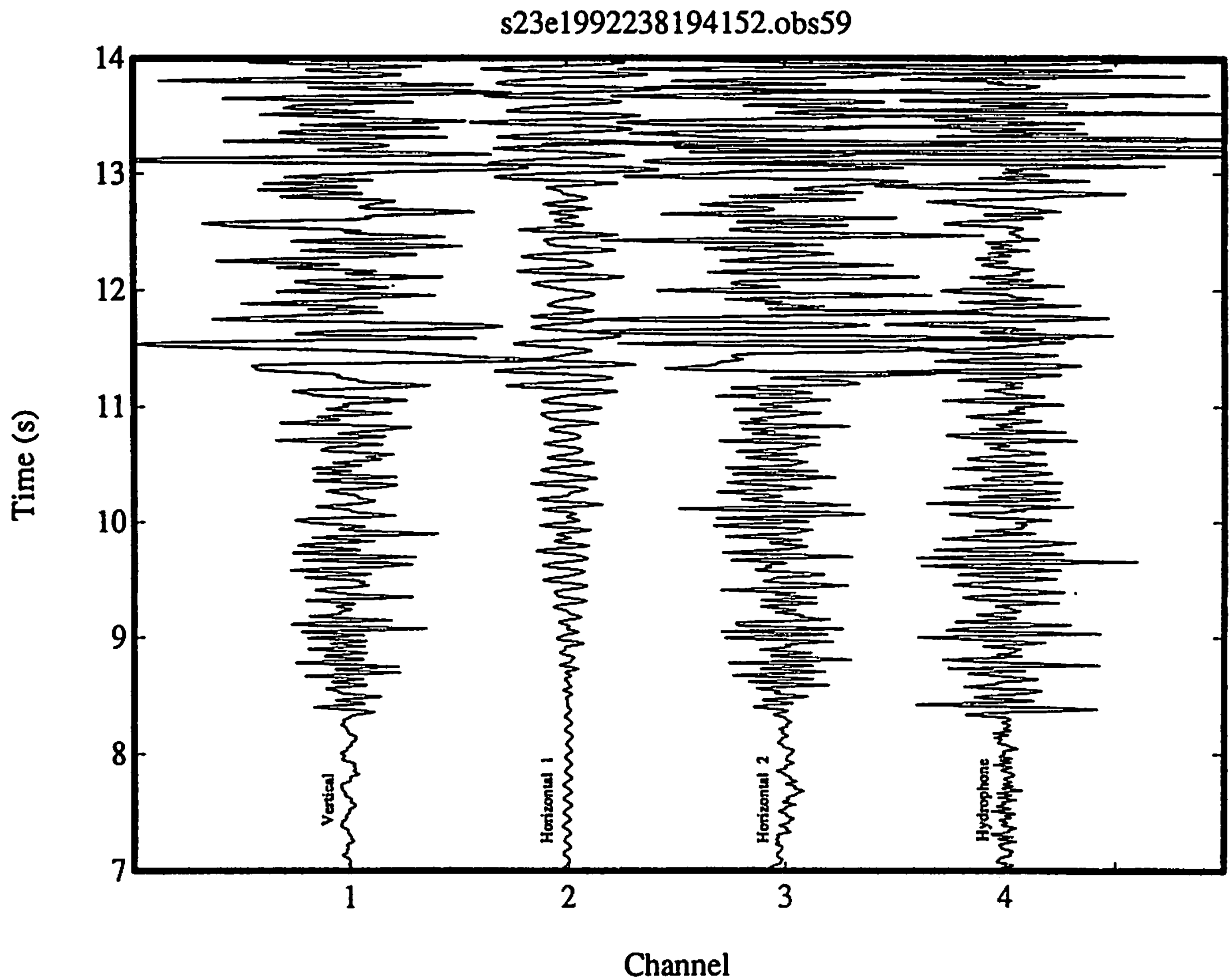


FIGURE A9.7 OBS#59 A smaller event with much lower signal to noise ratio, and a poorly defined shear wave arriving approximately 3 seconds after the P. But the first break on the hydrophone channel remains clear and impulsive.

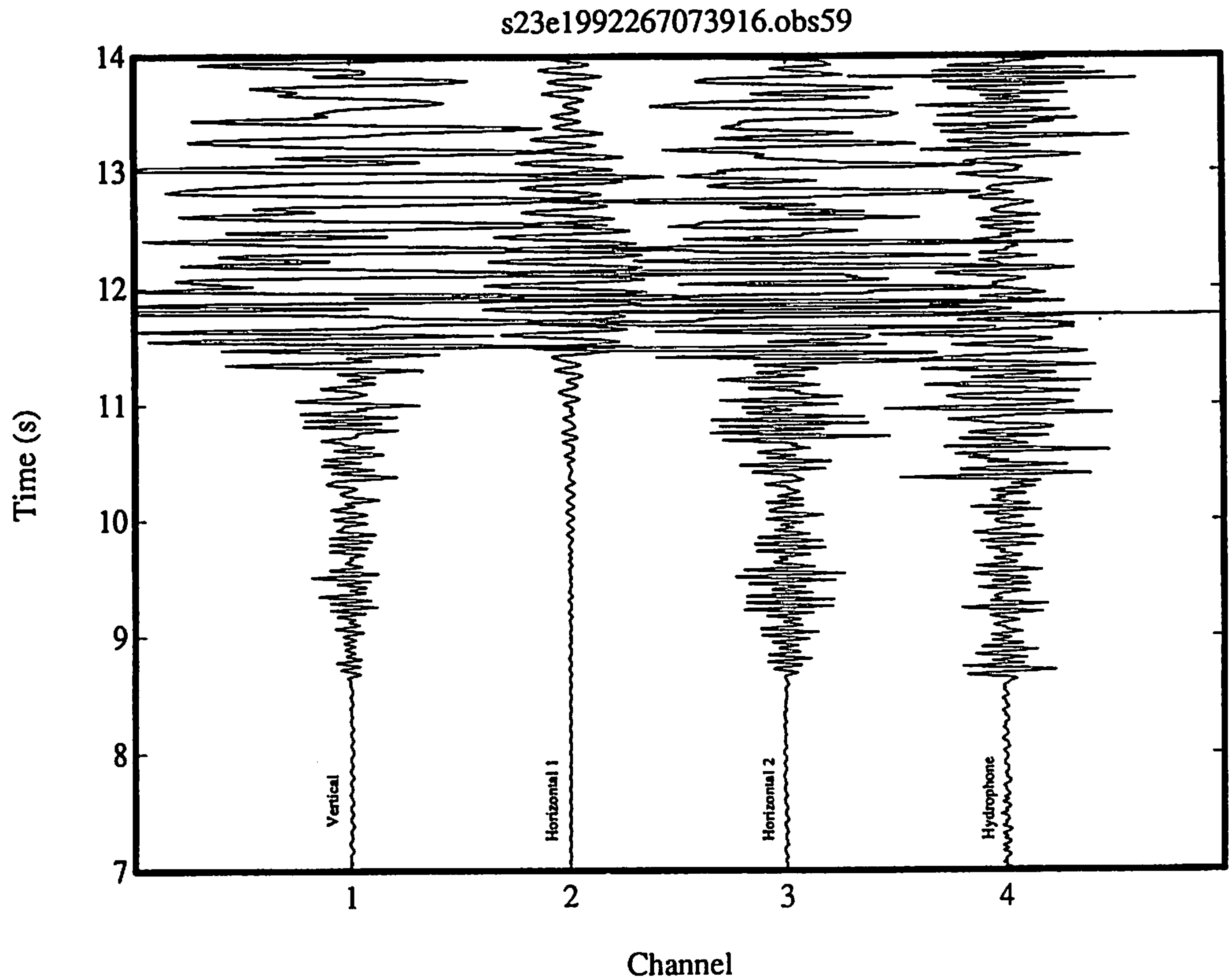


FIGURE A9.8 OBS#59 An example of a clear shear wave arriving 2.8 seconds after the P wave.Note that almost no first arriving energy is observed horizontal channel 1.

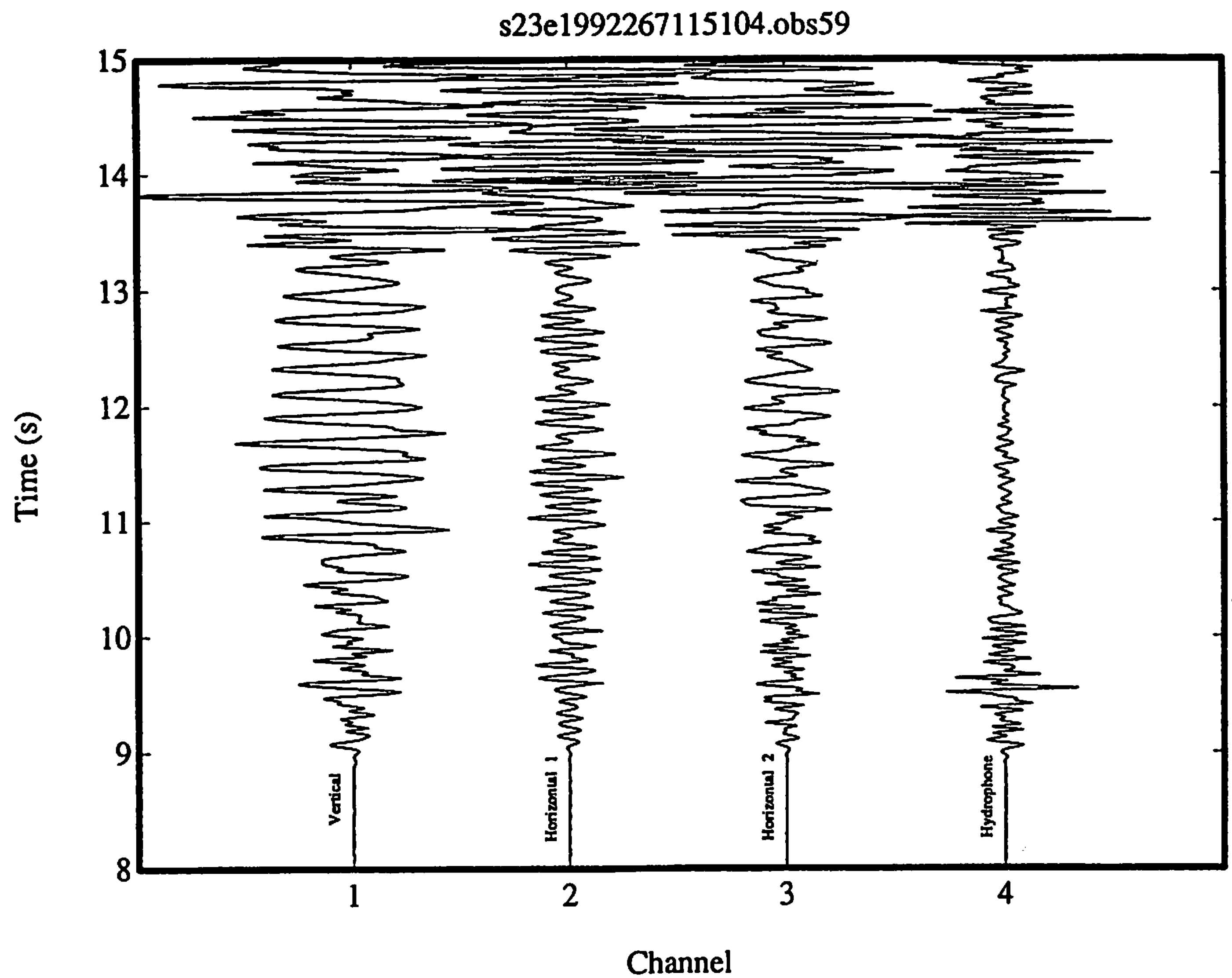


FIGURE A9.9 OBS#59 A clear event but without a large amplitude shear wave arrival. As in Figure A9.6 the water column multiple is visible on all four channels.

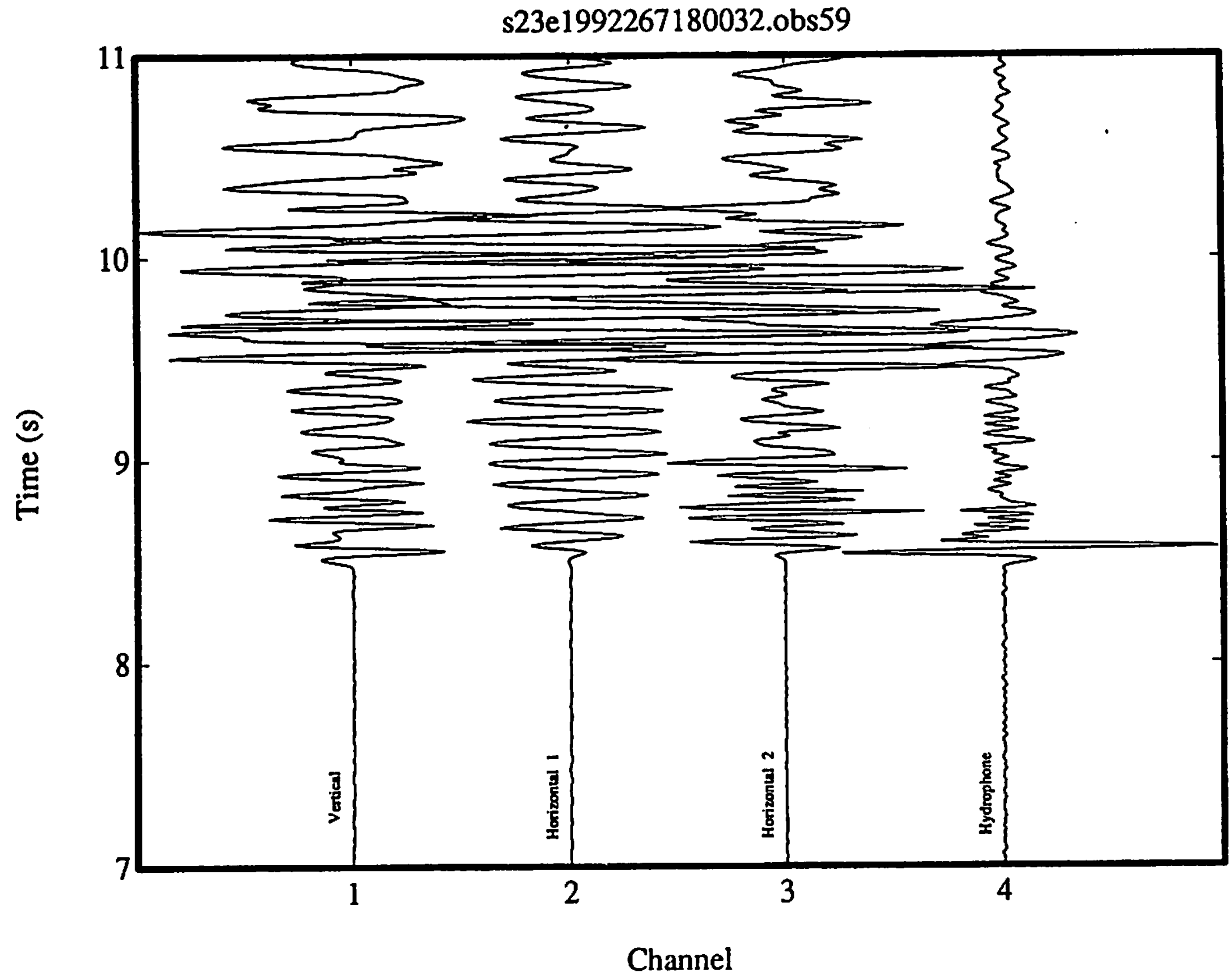


FIGURE A9.10 OBS#59 A near-by event with clear shear wave arrivals less than 2 seconds after the P and extremely clear impulsive first breaks.

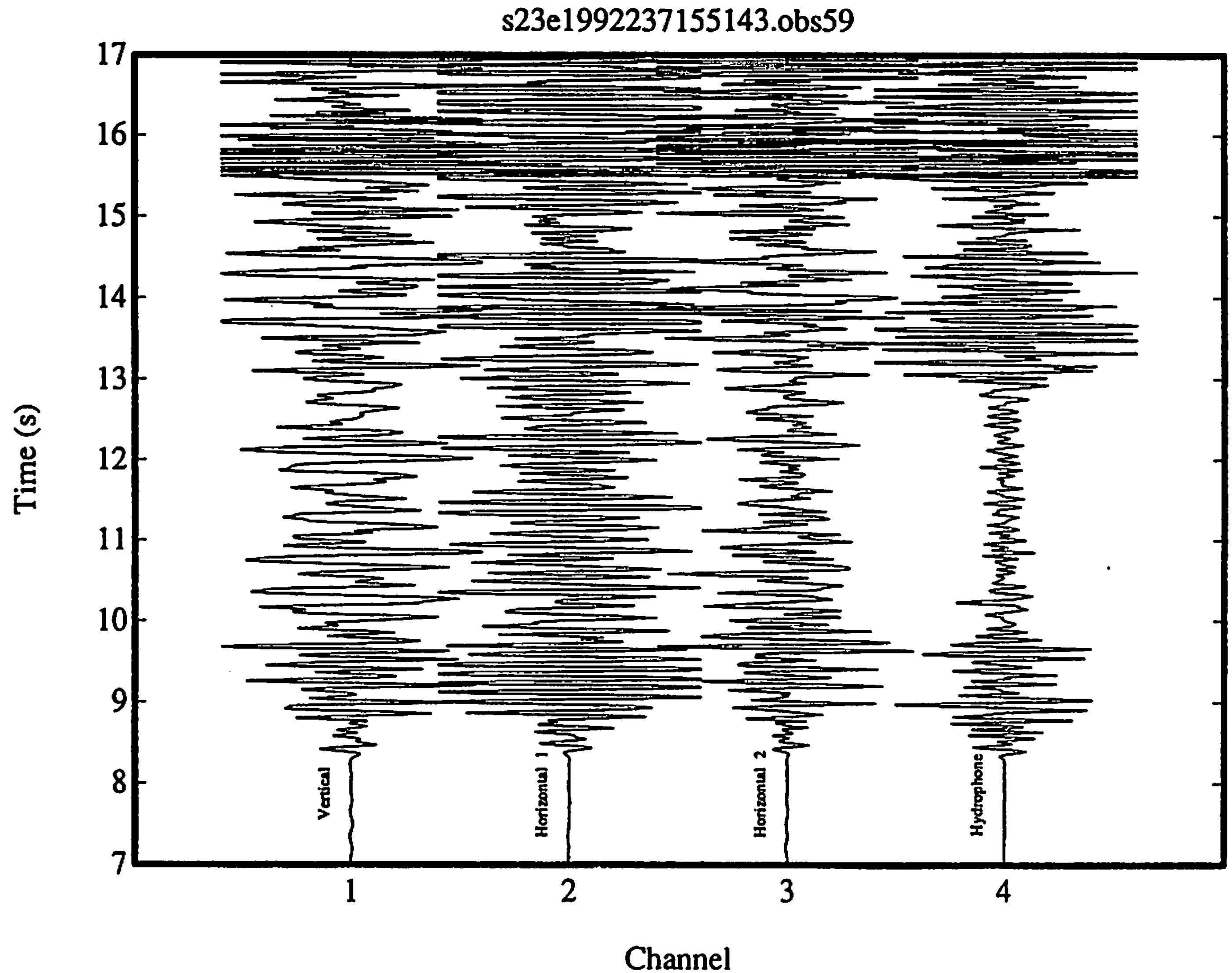


FIGURE A9.11 OBS#59 A 60 lb explosive charge detonated 20 km from the OBS along the median valley produces clear first arrivals on all four channels. The water wave arrivals have been clipped by the plotting program for display purposes.

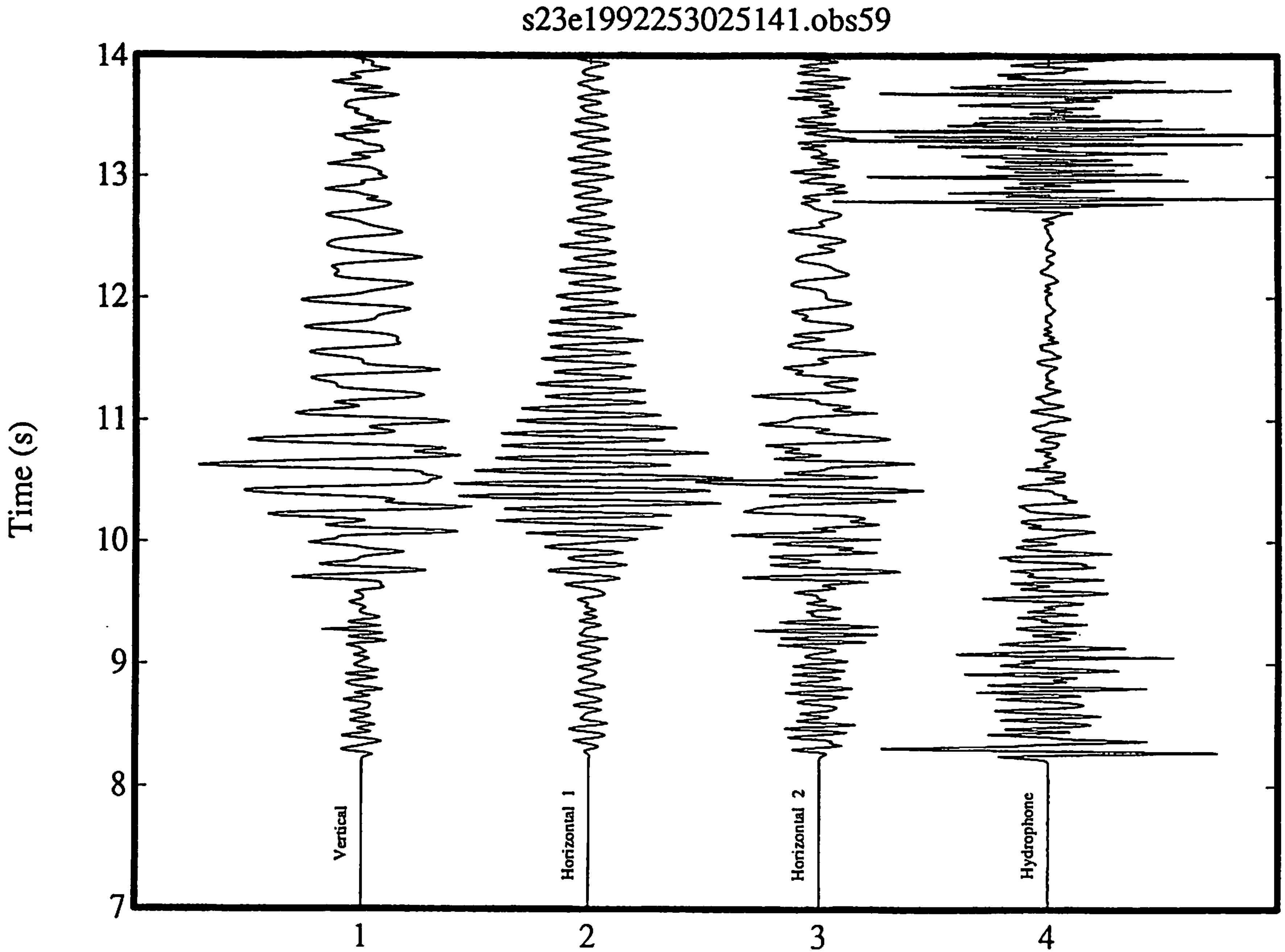


FIGURE 10 An example of seismograms from a good microearthquake event. The P wave first arrivals on the hydrophone and vertical seismometer channels are impulsive and good shear arrivals are identifiable. The P-S time is approximately 1.5 secs.

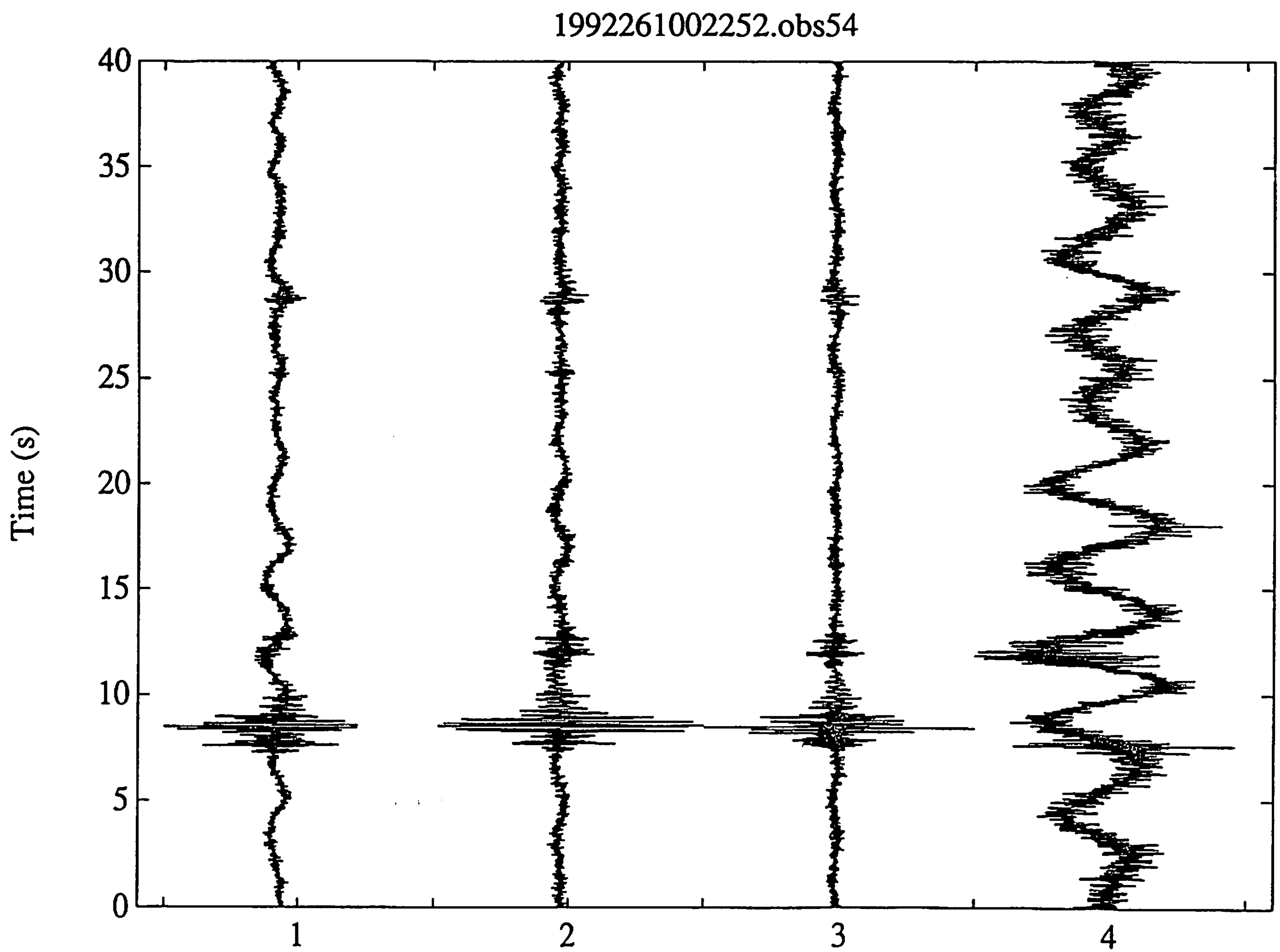


FIGURE 11 An example of seismograms from a small microearthquake event recorded by OBS #54. The arrival is hardly visible on the hydrophone channel (4), that coincidentally shows strong 5 second period microseism energy. Channel 1 is the vertical component and channels 2 & 3 are the horizontals.

APPENDICES

Appendix 1 Science Complement and Crew List 28
Appendix 2 Table of OBS Recoveries FARA 01 29
Appendix 3 Table of OBS Deployments FARA 02 30
Appendix 4 The Loss of OBS #55 31
Appendix 5 The Research Vessel MAURICE EWING 33
Appendix 6 OBS Performance during FARA.01 Part 1 35
Performance by Instrument 35
Performance Tables 62
FARA 01 Clock Drift Corrections 65
FARA 02 OBS Pre-Deployment Clock Checks 68
Modifications to the Hydrophone Pre-amplifier 70
Maxtor Recorder Issues 74
GRA spikes and Grounding 84
The OBS Control Loop 85
The 100MB Lab Test 87
Appendix 7 OBS Performance during FARA 01 Part 2 89
Summary 89
Appendix 8 FARA 02 Test 91
Appendix 9 Examples of Good Data from FARA 01 99
Appendix 10 New Check Lists 111
Appendix 11 Mechanical Modifications to the ONR OBS 125
Appendix 12 Acquisition Programs FARA.01&FARA.02 131
Appendix 13 FARA 01 Shot Table and Location Figures 132
Appendix 14 FARA 02 Airgun Shooting Tracks 145
Appendix 15 Data Handling and Processing 147
Data Handling on EW9210 147
Plans for a Matlab Microearthquake Data Reduction System 154
Appendix 16 Clocks 160
Appendix 17 EG&G Acoustics System 164
Appendix 18 Data List 165
Appendix 19 Hydrosweep Survey 167

Appendix 1 Science Complement and Crew List

Science Complement

John W. Bailey	WHOI
Andrew H. Barclay	University of Oregon, Eugene
Philippe Blondel	University of Washington, Seattle
Anne R. Briais	Institut Physique du Globe, Paris
S. Budhypramono	LDGO
David L. DuBois	WHOI
Toshiya Fujiwara	ORI, University of Tokyo
Louis B. Geli	IFREMER, Brest
John T. Hallinan	WHOI
Nobuhiro Isezaki	Chiba University, Tokyo
William J. Koczynski	LDGO
Lindsay Parsons	IOS, Wormley, U.K.
Philippe P. Patriat	Institut Physique du Globe, Paris
G.M.Purdy	WHOI
Celine Rommevaux	Institut Physique du Globe, Paris
J-C. Sempere	University of Washington, Seattle
Joseph N. Stennett	LDGO
Douglas Toomey	University of Oregon, Eugene
Cecily J. Wolfe	WHOI/MIT
Frank B. Wooding	WHOI

Officers and Crew

James E. O'Loughlin	Master
Stanley P. Zeigler	Chief Mate
David L. Phillips	Second Mate
Mark C. Landow	Third Mate
Blaine A. Heinz	Bosun
David G. Graham	A/B
Larry W. Barros	A/B
John A. Patch	A/B
Gil E. Newton	O/S
Javier A. Ureta	O/S
Stephen M. Pica	Chief Engineer
Gary G. Gould II	First Engineer
Joseph E. Walla	Second Engineer
Matthew van Duyne	Third Engineer
Richard D. Reid	Oiler
Michael '. Spruill	Oiler
Guillermo F. Uribe	Oiler
Gregory K. Gray	Wiper
Francisco N. Matos	Electrician
Frank Paloney	Steward
Tim F. Hummel	Cook
Luke Moqo	Messman
Pete A. Martin	Radio Operator

Appendix 2 Table of OBS Recoveries FARA 01

OBS #	ACQ S/N	REC S/N	SEN S/N	DATE/TIME	LAT.	LON.
50	15	32	31	10/06/92 00:59	29° 10.53' N	43° 08.80' W
51	25	34	07	10/04/92 19:18	28° 57.68' N	43° 17.77' W
52	59	38	24	10/05/92 14:20	29° 05.00' N	43° 08.46' W
53	17	3A	16	10/04/92 23:55	28° 55.32' N	43° 10.44' W
54	33	40	15	10/06/92 03:06	29° 09.93' N	43° 11.50' W
55	29	2A	33	*Unrecovered*		
56	11	36	09	10/05/92 12:14	29° 02.64' N	43° 11.19' W
57	31	3C	28	10/05/92 04:42	29° 00.25' N	43° 14.59' W
58	27	28	13	10/04/92 17:08	*Unavailable*	
59	23	26	29	10/04/92 21:41	28° 56.39' N	43° 13.67' W
60	55	2C	11	10/05/92 19:32	29° 07.71' N	43° 09.60' W
61	51	2E	04	10/05/92 22:33	29° 08.43' N	43° 06.63' W
62	13	30	32	10/04/92 14:33	28° 52.71' N	43° 13.77' W
63	19	42	14	10/05/92 02:23	28° 58.80' N	43° 10.28' W
64	21	24	27	10/05/92 17:22	29° 07.62' N	43° 13.20' W

Appendix 3 Table of OBS Deployments FARA 02

FARA 02 TEST

OBS No.	ACQ S/N	REC S/N	SENSOR S/N	DATE/TIME(GMT)		LATITUDE	LONGITUDE	DEPTH(m)
54	33	40	15	10/13/92	15:20	29° 18.28' N	42° 53.61' W	3331

FARA 02

OBS No.	ACQ S/N	REC S/N	SENSOR S/N	DATE/TIME(GMT)		LATITUDE	LONGITUDE	DEPTH(m)
50	15	32	31	11/01/92	18:28	34° 49.20' N	36° 25.19' W	2121
51	25	34	07	11/01/92	22:02	34° 52.03' N	36° 28.97' W	1807
52	59	38	24	11/01/92	23:05	34° 53.79' N	36° 25.25' W	2215
53	17	3A	16	11/01/92	10:12	34° 45.00' N	36° 25.10' W	2030
54	33	40	15	11/01/92	16:02	34° 44.12' N	36° 28.49' W	2620
56	11	36	09	11/01/92	14:41	34° 45.18' N	36° 30.51' W	2475
57	31	3C	28	11/01/92	17:01	34° 47.00' N	36° 25.30' W	2204
58	27	28	13	11/01/92	17:51	34° 48.48' N	36° 27.40' W	2316
59	23	26	29	11/01/92	21:07	34° 50.19' N	36° 29.04' W	1926
60	55	2C	11	11/01/92	19:53	34° 50.70' N	36° 26.29' W	2276
61	51	2E	20	11/01/92	19:15	34° 52.22' N	36° 24.52' W	1988
62	13	30	32	11/01/92	12:25	34° 46.29' N	36° 27.45' W	2469
63	19	42	14	11/01/92	13:34	34° 47.49' N	36° 29.76' W	2343
64	21	24	27	11/01/92	22:36	34° 52.83' N	36° 26.68' W	2236

Appendix 4 The Loss of OBS #55

OBS #55 was deployed from the Research Vessel OCEANUS 21st. August 1992 at 1938Z at 29 05.58N 43 11.69W in a water depth of 3115 uncorrected metres. At 1450Z on 5th October 1992 the Research Vessel MAURICE EWING hove to over the instrument and began the normal release procedures. The EG&G transponder release (Model 8242) serial number 13652 was enabled without difficulty and ranges of 3115-3117m were recorded. At 1451 the first release command was transmitted but no response was received. At 1452 a second release command was sent and a clear one second timed ping was received indicating that the release command had been received and acted upon. However when interrogations were recommenced ranges of 3119m,3120m, and 3121m indicated that the instrument had not left the seafloor. This should never happen. At 1454Z a third release command was sent and again a clear one second timed ping was received but upon interrogation ranges remained 3116m,3119m,3117m. The disable command was sent to this unit at 1455Z and this was acknowledged with a clear one second timed ping.

We then switched to the interrogation of the other transponder serial number 14156. This was easily enabled at 1456Z and upon interrogation ranges of 3117m and 3118m were recorded. The release command was sent at 1457Z and a one second ping was heard although this was somewhat intermittent.Upon interrogation ranges remained at 3121m, 3123m, 3116m, 3117m, 3117m. There was a noticeable and unusual tendency for the ranges to jump around by 4-5m. But the instrument remained on the seafloor.This should never happen. At 1500Z a second release command was sent to unit 14156. A solid one second timed ping was received but again interrogation showed there had been no lift-off. At 1505Z a disable command was transmitted and this was acknowledged by a one second timed ping.

Unit 13652 was re-enabled at 1506Z and yet another release command was sent at 1507Z. A one second ping was again received but ranges remained at 3135 and 3134m indicating the OBS was still on the ocean floor. The instrument was left enabled while consideration was given to how we should proceed.

At 1529Z, after the research vessel had moved back over the OBS it was once again interrogated and ranges of 3115m were recorded. At 1531Z the disable command was sent to unit 13652, it was acknowledged by a one second timed ping and the vessel departed the area to continue recoveries of the remaining OBS.

At 2005Z 5th. October the vessel returned over the OBS and unit 13652 was once again enabled. Several good ranges of 3118m, and 3120m were recorded followed by several spurious readings. At 2011Z a series of good interrogations yielded ranges of 3136m, 3135m, 3140m. The disable command was transmitted at 2012Z and this was acknowledged by the usual one second ping. The research vessel then departed the area.

Our next return was at 0353Z 6th. October when we enabled unit 14156, recorded ranges of 3124m, 3129m,3124m,3112m,3112m,3114m,3120m, before sending the release command at 0356Z A solid one second ping confirmation was received but interrogation once again gave ranges of 3112m, 3113m, 3113m indicating the unit was still on the seafloor. The disable command was sent and the confirmation was received. Unit 13652 was enabled and ranges of 3115m, 3115m, 3115m recorded. At 0359Z a release command was sent, an intermittent one second ping was received but interrogations produced no solid replies until the ships transducer had been recovered and redeployed, when the usual ranges of 3119m, 3123m, and 3121m were recorded. At 0403Z the disable command was sent and receipt was confirmed by a one second timed ping.

Unit 14156 was again enabled,and ranges of 3115m, 3116m recorded. This unit was left enabled when we departed the area at 0405Z. 6th October.

On 12th October we returned to the instrument site one last time. In 25-30 knot winds we hove to over the instrument site at 0925Z and received immediate response to our interrogations of the unit 14156. Ranges were 3113m, 3113m, 3114m. At 0926Z we transmitted a release command to this unit and easily recorded the one second time ping reply. Further interrogations yielded ranges of 3114m, 3114m, 3114m, 3115m. At 0928Z we recovered the transducer and departed the area leaving transponder 14156 in the enabled mode.Our GPS location at that time was 29 05.55N 43 11.84W

Both transponders had performed well throughout the interrogations. The only anomaly (and it was a small one) was the fact that the ranges tended to jump around by 5m or so. But the acoustic contact was good and we received many many one second time ping responses from both units. The time pinger is switched from a two second rate to a one second rate by a microswitch that is activated by the mechanical motion of the solenoid that actually performs the release.So all evidence supports the conclusion that both transponders are in a released state. There is sufficient buoyancy in the system for recovery to take place if one glass ball is broken, or if one of the pressure cases is flooded.The most probable scenario is that the instrument is somehow jammed or trapped in the rough topography of the median valley of the Mid-Atlantic Ridge. Perhaps the instrument is anchored by its sensor package that is trapped down a small fissure.

We knew that the French research vessel NADIR with the submersible NAUTILE on board would be passing close by this location in November on passage from the Azores to the Kane Fracture Zone. The Chief Scientist would be Jean-Marie Auzende, and Maurice Tivey from WHOI would be on board. We immediately contacted Jean-Marie by e-mail to determine if there was a possibility for him to dive on and recover our OBS Early responses to this request were in principle very positive, although the proximity of the glass balls to the submersible presented a hazard that may prevent a sufficiently close approach to attach a line and pull the OBS from whatever obstruction is causing our problem.

Appendix 5 The Research Vessel MAURICE EWING

It is obvious from the descriptions of successful operations in this report that we were able to function effectively from the Research Vessel Maurice Ewing. With an overall length of 238 feet and a displacement tonnage in excess of 2600 tons, she is a large ship by the standards of US acedemic research vessels and rides very comfortably. Substantial lab space was available. The OBS operations were centred in the Dry Staging area. Two Sun workstations, laser printer, three 386 PC's, chart table, and all electronics repair bench space were in this area. The pressure cases (thirty 5 foot long 7" ID cylinders) were stored in their racks in the Wet Staging area that was immediately aft of the previously described space. The OBS frames were distributed on deck (Figure A5.1) and because no problems were experienced with the acoustic release systems these remained on the frames throughout the voyage. The decision not to bring our lab van was clearly a good one - we were able to function very well using the ships laboratory space and there is no location on deck where a van can be positioned that provides easy access into the interior of the vessel and onto the fantail. Any van placed on the fantail would have to be raised significantly off the deck.

All OBS recoveries were performed from the most forward portion of the starboard waist deck. This was the only reasonable location for such operations. Further aft the waist deck is covered and it is impossible to effectively wield a long boat hook when the inboard end of the pole is hitting the deckhead. Further aft, on the fantail, where the overhead is clear, the shape of the ships sides is completely unsuitable for recovery operations - the substantial overhang presents a significant risk of damage to instruments getting 'underneath' the ship and being damaged during even modest rolls. Recoveries were carried out in the normal way with a detachable hook on the pick-up pole that was transferred to the hook of the small crane that is positioned immediately above the forward waist deck on B deck. Little difficulty was experienced in the recoveries. With no bow thruster, a single screw, zero visibility of the waist deck from the bridge and no controls on the bridge wings, EWING was more difficult to maneouver alongside the instruments than most research vessels. It is a testament to the skill of the Captain and Mates that they were able to retrieve all the OBS from such a short section of deck without damage or great difficulty. Deployments were carried out over the stern using the fantail crane and our own release hook.

The lab based science support facility that was of the most value was unquestionably the computer network. LDGO systems engineer Budhypramono supplied much needed systems support for our SUN workstations. Access to the laser printers and to supplementary computing power was of immeasurable value.Communications were excellent - the e-mail system was reliable and proved essential to the solution of a couple of technical problems with the OBS by providing easy access to engineers back at WHOI. For more urgent traffic the radio operator solved more than one crisis by judicious use of the INMARSAT fax system. Because of the at-sea modifications that were required on the OBS it was necessary to request the assistance both of the Chief Mate and the Deck Department in locating hardware components and of the Engineering Dept.in locating raw materials for modifying the anchor system, and most importantly for help in welding a total of 56 eyes on the steel anchor plates. We received complete co-operation: help was provided willingly and was crucial to our ability to successfully complete our instrument redeployments. Construction of the new soluble release system for the external seismometer packeages was only possible because of the interest and co-operation of the Galley Dept who assisted with our efforts to manufacture large volumes of molten sugar!.

The quality of navigation, both in the positioning of the OBS for deployment and for maintaining our position along tracks during Hydrosweep surveyng or airgunning was uniformly excellent. The airguns performed reliably (once they got going!) and were launched and operated without difficulty.

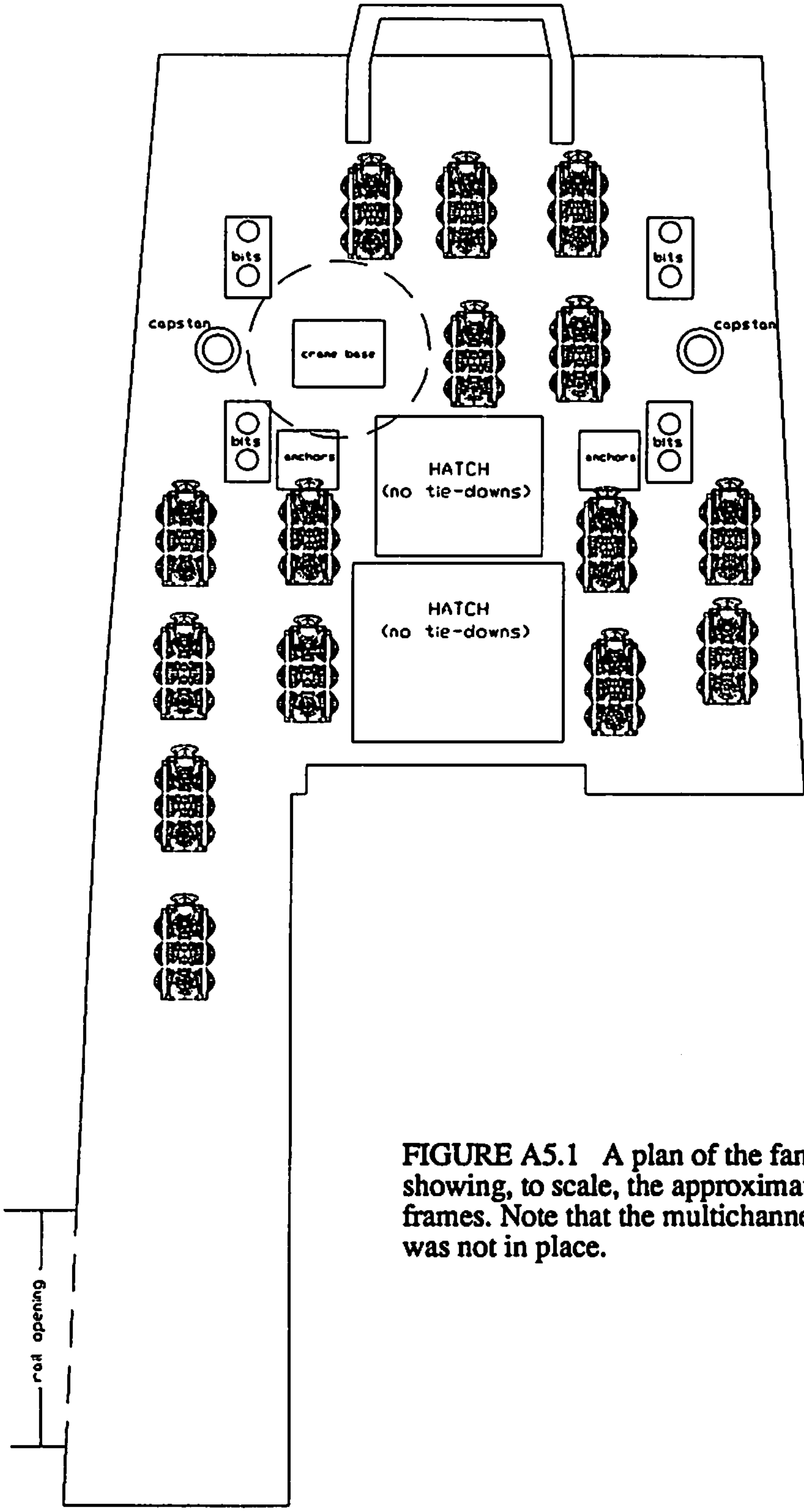


FIGURE A5.1 A plan of the fantail of the EWING showing, to scale, the approximate distribution of the OBS frames. Note that the multichannel hydrophone array winch was not in place.

Appendix 6 OBS Performance during FARA.01 Part 1

Performance by Instrument

In this section examples of the data recorded by the OBS will be presented and the problems associated with each of the instruments described, along with our best estimates, at the time of writing, of the causes of the failures. These discussions will rely heavily upon the data presented in the Tables A6.1 and A6.2. The schedule for data acquisition during FARA.01 is presented in Appendix 12. These paragraphs below are the final evolution of text that was constantly updated during the process of evaluation of instrument performance. On the basis of these assessments requirements were set for further data plotting or hardware tests that were considered necessary before re-deployment.

OBS #62 This instrument recorded no data on optical disc and, due to an oversight during the post-recovery debriefing (this was the first instrument to be recovered) the data in the recorder memory was lost. So almost no information exists regarding performance during FARA.01. The RSLI showed that the sensor package was on its side, its bail was bent off center, and ample evidence of sediment on the sensor package and in the frame legs was observed. Forty-one failed attempts to write to disc were made and the 28v power for the Maxtor was dead. We speculate that these observations can be explained by the following The frame came to rest on the sea floor at an angle greater than 15 degrees. Because of this tilt the Maxtor was unable to write and eventually got hung up in its time-out loop (because of a recorder software error - the semi-colon) and drained the 28v power supply. Given the direction of distortion of the bail it is likely this damage occurred upon lift-off of the unit from the seafloor. This instrument had a 'G' series hydrophone sensor so there is some reason to believe good hydrophone data would have been recorded even if the seismometers were inoperative. The SEASCAN clock drift of 108 ms is substantially outside specifications but would have been correctable. (This instrument with the same electronics packages was used for FARA Test 04 on the OCEANUS cruise and showed no problems).A post-recovery shipboard test in which 16 Mb of sine wave data were recorded on the optical disc showed no errors, no dropped bytes, only the generic erroneous gain range header problem. Inspection of the interior of the sensor package revealed no evidence of mechanical damage.This instrument will be deployed for FARA.02 essentially without modification.

- **ACTION:** **Data** None
  Hardware Check sensor gimbals(CSG), comparison check of sensor performance (CCSP) paying special attention to Channel #3 (some unusual waveforms seen in TEST 04). Check hydrophone channel (CHC)

OBS #58 This instrument recorded a full optical disc but its sensor package did not deploy. The acquisition package had slid significantly towards the sensor package end of the frame - presumably (but certainly not for sure) upon impact with the seafloor.The 28v power supply was good and some reasonable seismograms were recorded on the vertical seismometer and hydrophone channels. It is surprising that the vertical component operates at all, given its tilt angle in the deployment arm cradle.The Seascan clock drift was only 36 milliseconds.A total of 5071 event triggers occurred, 2133 during the hydrophone sensor phase and 2938 during the vertical seismometer phase.The two dead horizontal seismometer channels exhibit clear one second GRA spikes, falling regularly and clearly on the one second boundaries and absolutely no signal whatsoever. These same spikes are seen on the hydrophone channel that, during hydrophone event detect mode, recorded typical noise levels with Collins amplitudes of 3000-4000 peak-to-peak (see Figure A6.1). For a large portion of the deployment the hydrophone (which was a 'G' series) seemed to operate satisfactorily but its data was seriously marred by the generic GRA one second spikes.A first quick look at events during the hydrophone event-detect phase showed that, out of 81 events 34 were spurious. The vertical seismometer was fully operational (at least on day 238) and generally showed a better signal -to-noise ratio than the hydrophone channel. (e.g. Figure A6.2). Some excellent records were obtained (e.g. Figure A6.3). Inspection of small portions of the continuous recording phase showed two interesting characteristics. Very prominent transients are observed that are associated with the power-up and activation of the Maxtor optical disc drive. And in some cases a coincidence is noted between this activation and the appearance of GRA spikes. An interesting example of an important mode of instrument failure is shown in Figure A6.4, that illustrates an approximate one second long segment of data within which the gain on all four channels seems to have been inexplicably reduced by approximately 20 dB.This same figure illustrates another important point: it can be immediately seen that the traces of channels two through four are perfectly coherent. The hydrophone noise level however is substantially larger (20,000-30,000 Collins counts) than previously. This was documented on Day 276 for both the continuous record and the event detect phases on that day. No physical understanding of this exists at this time. The coherency phenomenon in the past has been associated with very low signal levels (i.e. all that was being seen was the noise floor of the electronics which understandably could be coherent from one channel to the next): wrong gain information in the header could explain this but it is difficult to devise a means of checking this. The hydrophone did in fact continue to function at some level. Further interpretation of these observations is as follows. The sensor did not deploy because the release foot never came into contact with the seafloor.Because of the tilt of the main frame and the way the sensor package sits in its arm, then both horizontal seismometers were against their stops and only the vertical sensor could function. Because the horizontal seismometers were up against their stops, the grounding of the instrument was changed such that the A/D generated spikes on several of the channels. Some kind of failure, source unknown, occurred in the hydrophone channel at some time prior to Day 276.

- **ACTION** **Data .** None
  Hardware CSG,CCSP, identify cause of hydrophone failure and fix.

OBS #51 This instrument recorded 215 Mb on disc but no useful seismometer data and the hydrophone was of poor quality (#1134 - not a 'G' series!).The sensor package RSLI indicated that the sensor was severely tilted and sediment was clearly detected on the sensor package connector, on the sensor package chain and in the corer. The Seascan clock had a good low drift of only 18ms. 932 event triggers occurred of which only four were activated by the vertical seismometer and these were extraordinary dc shift events on the 9-10 second boundary (Figure A6.5). Some reasonable events were recorded by the hydrophone but the data were dominated by one second GRA spikes (Figures A6.5 and A6.6). Hydrophone noise levels were approximately 20,000 collins counts peak-to peak in event detect mode.but they reached values as high as 50,000 in places during the continuous record phase.Subjectively the instrument worked as well (or as badly) in continuous record phase as it did in event detect. Some concerns must exist because no useful data were recovered from the seismometers. One possibility is that the gimbals jammed against the side of the package and could not level in any plane. Tentative interpretation of these results is that the seismometer package was tilted such that all three components were against their stops and produced no output. The resultant large GRA spikes on the hydrophone increased the long term average on that channel sufficiently that only the large events were recorded. The relationship between seismometers against their stops and the prominence of the GRA spikes is reaffirmed here. During the post -recovery check of the interior of the sensor package the signal wires were found to be wrapped around one of the gimbal balancing weights.

- **ACTION** **Data** None
  Hardware CSG, a particularly careful CCSP, and a very careful CHC and replace hydrophone sensor #1134 with G10.

OBS #59 This instrument recorded a full disc and all four channels functioned. A total of 7030 event triggers occurred and the Seascan clock drifted by 37 ms. The RSLI indicated tilt near the 15 degree limit of the gimbals, and no sediment was recovered. The 28 volt Maxtor battery pack was dead presumably because of the instrument's attempts to write substantially more than 400 Mb to the disc. Noise levels on the 'G' series hydrophone were 2000-3000 Collins units peak-to-peak. Large numbers of excellent events were recorded (e.g. Figure A6.7).For example, 188 triggers occurred on day 267 of which approximately 110 were real events, 14 were obviously spurious noise triggers and approximately 50 were small noise bursts, perhaps tiny events. A few curious oscillatory events were recorded on the seismometers, but with no signal on the hydrophones e.g. Figure A6.8 - we suspect a biological source. 3-4 Hz oscillations pervade the vertical and one of the horizontal channels and seems to have almost exactly opposite phase on the two channels. Many false triggers were generated on the vertical hydrophone by oscillatory noise bursts. At first look this seems to be by far our best instrument. The continuously recorded data was of comparable quality to that recorded in event detect mode. Interestingly there is a clear coincidence between a lack of dead channels and a lack of GRA spikes. No GRA spikes were observed on this instrument.

- **ACTION** **Data** None
  Hardware CSG CCSP

OBS #53 This instrument recorded only 16 Mb on disc although it attempted to write separate 4 Mb blocks 256 times!. So the 28 volt supply was dead. The RSLI indicated a sensor tilt of more than 15 degrees but the sensor was not on its side. Sediment was recovered. Reasonable data were recorded on all four channels and as with #59, no large one second GRA spikes were evident. Channel 2 (one of the horizontal seismometers) had no response above 8.5 Hz .The instrument recorded 461 events and the last data on disc was dated day 238. The last data in the recorder memory was dated 267. Is this 29 day separation between when the disc stopped recording and when the UART got turned off understandable? Hydrophone noise levels peak-to-peak were about 4000 Collins units, but they varied substantially occasionally up to several tens of thousands - sometimes slowly, sometimes abruptly. It was tempting to try to relate these changes to the many attempts by the Maxtor to write to disc (transients which might be caused by the Maxtor were observed) - and this is the most reasonable explanation but a conclusive case cannot be established. It is presumed that excessive tilt on the Maxtor drive prevented recording of data One of the clock checks was lost so the clock drift number is only an estimate based on the observed drift rate of the clock before the experiment.

- **ACTION** **Data** None
  Hardware CSG CHC CCSP

OBS #63 This instrument recorded a full disc of data but the hydrophone channel (sensor #1140) was non-functional. The RSLI showed that the sensor package was severely tilted (more than 30 degrees) and considerable sediment was recovered. The Maxtor 28v power was dead and the Seascan clock drifted 124 milliseconds. A total of 5318 triggers occurred of which 2043 were generated by the hydrophone channel. Classic examples of one second GRA spikes are shown in Figure A6.9. The majority of the triggers were spurious during the time when the hydrophone sensor was being used to declare the events . During one period totalling approximately 30 hours, of the 80 triggers that occurred, only 18 could be classified as 'real'. One example of a reasonable record is shown in Figure A6.10. A 12Hz resonance is observed on the seismometers and in vertical event detect mode out of 206 triggers on Day 267 100 events were inspected and 40-50 were identified as clear events. Some false triggers were generated by the 'one second bogus gain jumps' The last data in recorder memory was timed at 0700Z on Day 278. Why did it stop three hours too soon? This instrument, besides the rather poorly adjusted Seascan, clearly has a defective hydrophone sensor.

- **ACTION** **Data** None
  Hardware CSG, Replace hydrophone #1140 with M1327 ,CHC,CCSP

OBS #57 This instrument recorded 225 MB on disc but its sensor did not deploy.The Seascan clock drifted the least of any of the OBS - only 17 milliseconds. The 28 volt Maxtor battery was not depleted.The instrument recorded 1171 event triggers and some arrivals were observed on two of the seismometer channels and the hydrophone(#1138). Sections of the hydrophone data are made practically useless by very bad one second spikes (e.g. Figure A6.11) One example of a good record is shown in Figure A6.12. During the period in which the hydrophone sensor was used to declare events many of the 793 triggers were spurious but while the vertical seismometer was being used event detection seemed reliable with, on average, about 15-25 events per day.The exception was the last day of event detection, 2nd October (Julian Day 276) when 70 events were recorded in a 12 hour period. Also during the event detect phase the hydrophone noise level was approximately 40,000 Collins units peak-to-peak, 20 dB greater than 'normal'. Performance in event detect and continuous record phases was about the same. An intriguing data segment in the continuous record phase shows a clean change on the rate of the GRA spikes. The last data on disc was at 0953Z on day 278 and the cal sequence was in the recorder memory. Our interpretation of this instruments performance is as follows: The sensor package did not deploy because the footpad never came into contact with the seafloor.The frame was within 15 degrees of the horizontal so no problems were encountered with writing to the Maxtor. Because the sensor package remained in the deployment arm one of the horizontal components was against the stops and produced no useable data. Bad one second GRA spikes on the hydrophone channel seriously marred the first phase of event detection which may have been made worse by a partially defective hydrophone sensor. Lab tests revealed a possible problem with gain setting in channel 2 of the sensor package.

- **ACTION** **Data** None
  Hardware CSG, a particularly careful CHC, replace hydrophone sensor #1138 with G11.

OBS #56 This instrument recorded 336 MB on disc and more than 4400 events. The RSLI indicated that the sensor package was within 15 degrees of level and the Seascan clock drifted only 62 milliseconds.The 28 volt Maxtor battery was not depleted upon recovery, and little evidence of sediment was recovered on the instrument. The three seismometer channels operated well but the hydrophone channel (sensor G6) was seriously defective with very high noise levels of 20000-30000 Collins units and many large spikes. Although the hydrophone did function at some level,as is clear from the shot record shown in Figure A6.13, the majority of the data were unusable (e.g. Figure A6.14). Our interpretation is that the sensor was well deployed and the frame rested near the horizontal, so there were no Maxtor problems and all the seismometers were good. The hydrophone channel is bad either because of the sensor itself or because of some fault in the electronics. The instrument seemed to have functioned in vertical event detect mode but no continuous data was recorded (Why not?). The last event was timed at approximately 1815Z an Day 275.

- **ACTION** **Data** Plots of vertical events , late in the deployment
  Hardware CSG, a particularly careful CHC, replace hydrophone sensor G6 with G12.

OBS #52 This instrument recorded only 16 MB of data (a total of 280 events triggers)and the 28 v Maxtor battery was dead. The data suffered from the presence of multiple empty blocks. The RSLI indicated a sensor tilt of less than 15 degrees and the Seascan clock drifted 30ms. No useable data was recorded. It was subsequently determined that the digital GRA board was non-functioning and inspection of the pre-launch deck test suggests that it was non-functioning at the time of launch. The supposition is that frame tilt caused the Maxtor failure (it tried to write to disc 256 times) and the depletion of the Maxtor batteries. The last data in recorder memory was timed at approximately 1800Z on Day 276 so the instrument started the cont recording phase but for unknown reasons failed before completion.

- **ACTION** **Data** None
  Hardware CSG,CCSP,CHC

OBS #64 This instrument recorded 331 MB on disc, but the RSLI indicated that the sensor package was on its side so only the hydrophone channel generated useable data and this was seriously marred by the one second GRA spike phenomenon. Seascan drift was 101milliseconds. The Maxtor 28 v power was not depleted upon recovery.During the hydrophone trigger phase large numbers of spurious events were recorded. For example, during Day 238 176 events were recorded and upon inspection of a randomly chosen subset of 30 of these only about 10 were found to be real and perhaps useful. The noise level on the hydrophone was approximately 4000-5000 Collins units peak-to-peak. In the continuously recorded data an excellent example exists of the GRA spikes (separated by more than one second in this case) being 'turned on' and then being 'turned off' by what we believe might be the Maxtor transients (Figure A6.15).The hydrophone during the continuous recording phase shows prominent spikes(Figure A6.16) , but nevertheless some excellent records are obtained (e.g. Figure A6.17). Although the seismometers did not function some large events were recorded during the vertical event detect phase: for example, on Day 267 among the false triggers generated by spikes and long period garbage two good large events were recorded. Our interpretation of these observations is that although the frame sat near the horizontal on the seafloor, allowing the Maxtor to function without difficulty, the sensor package, on its side, caused all three seismometers to be against their stops and so produce no useful data. Besides the GRA spikes the hydrophone channel functioned well.

- **ACTION** **Hardware** CSG,CCSP

OBS #60 This instrument recorded no data on the Maxtor, but apparently had four good channels with the RSLI indicating a sensor package tilt of about 15 degrees.The Maxtor 28v supply was dead. The data in the recorder package memory was dated August. The peak-to-peak noise on the hydrophone is about 5000 Collins units, ignoring the long period 4-5 second component. A random sample of 30 events from the total of 95 that were recorded showed that about 10 were spurious. This instrument apparently had four good sensors but tilt caused the Maxtor to 'hang-up', drain its batteries and turn-off the UART that stops flow of data on the serial link from the acquisition package to the recorder.

- **ACTION** **Data** None required
  Hardware CSG

OBS #61 A full disc was recorded on the Maxtor, the RSLI showed that the sensor package was close to the horizontal but the hydrophone was defective. A total of 7219 events were recorded, of which 4005 were triggered by the hydrophone and the remainder by the vertical component seismometer. The 28 v Maxtor power was dead. The Seascan clock drifted 38 milliseconds. Although a large amount of useful data was recorded by this instrument, many of the seismograms display characteristics indicative of malfunctions (Figure A6.18). All three channels are subject to a monotonic resonance of 11 Hz. During one day of the vertical trigger phase (Day 267) a total of 185 triggers occurred, the vast majority of which were real events. But many of the seismograms looked very weird - dominated by this 11 Hz resonance and extraordinary sections with constant amplitudes on channel 3. The hydrophone sensor and/or electronics is bad, and either the sensor package was poorly coupled to the seafloor in some extraordinary way, or there is also something wrong with the seismometer sensor package.Much sediment was recovered and the RSLI indicated a level package so it is difficult to believe the 'coupling' scenario. This sensor package should be replaced for FARA .02 whether or not any defect is recognized

- **ACTION** **Data** None required
  Hardware CSG, CCSP, replace the sensor package and the hydrophone sensor #1136 with M1328,CHC

OBS #50 This instrument recorded only 260 kilobytes on the Maxtor, the sensor package was severely tilted, and only 102 events were recorded, all during the hydrophone trigger phase of data acquisition.The Maxtor 28 v was dead and the Seascan clock drifted by 45 milliseconds. The vertical and one horizontal gave useable traces. The other horizontal was dead except for one second GRA spikes. The hydrophone gave some good shot records but elsewhere was seriously effected by the GRA spikes (Figure A6.19).The time of the chronologically latest data in the recorder memory was approximately 0654Z on Day 237. As with OBS#60 we suspect a combination of tilt and a deactivated serial link as the cause of the data loss. It is difficult to make a good assessment of hydrophone performance, dominated as it was by GRA spikes, but the noise levels were only 1000-4000 peak-to-peak and the shot records were reasonable. So the favored interpretation is that the hydrophone was working satisfactorily.

- **ACTION** **Data** None
  Hardware CSG,CCSP,CHC

OBS #54 This instrument recorded a full disc with three working seismometers that the RSLI showed were within 15 degrees. The 28 v Maxtor power was dead. The Seascan drifted by 32 milliseconds and 5789 events were recorded of which 3070 occurred during the hydrophone trigger phase of the acquisition program.. The hydrophone channel has intermittent major glitch problems but few 1 second GRA spikes are seen. In fact one place they are clearly visible is in association with the Maxtor turn-on sequence. But there several good four channel records of events (e.g. Figure A6.20). Last data in recorder memory was at 0906Z on day 278 and the last data on disc was at approximately 0127Z on that same day. Our interpretation of these observations is that this instrument functioned satisfactorily except for intermittent failures of the hydrophone channel due to causes unknown. When the hydrophone sensor was replaced on this unit for FARA 2 Test all four channels operated flawlessly, although some minor questions remain concerning the absolute sensitivity of the hydrophone.

● ACTION	Data	None
	Hardware	Use same hydrophone as for FARA 2 Test, CSG

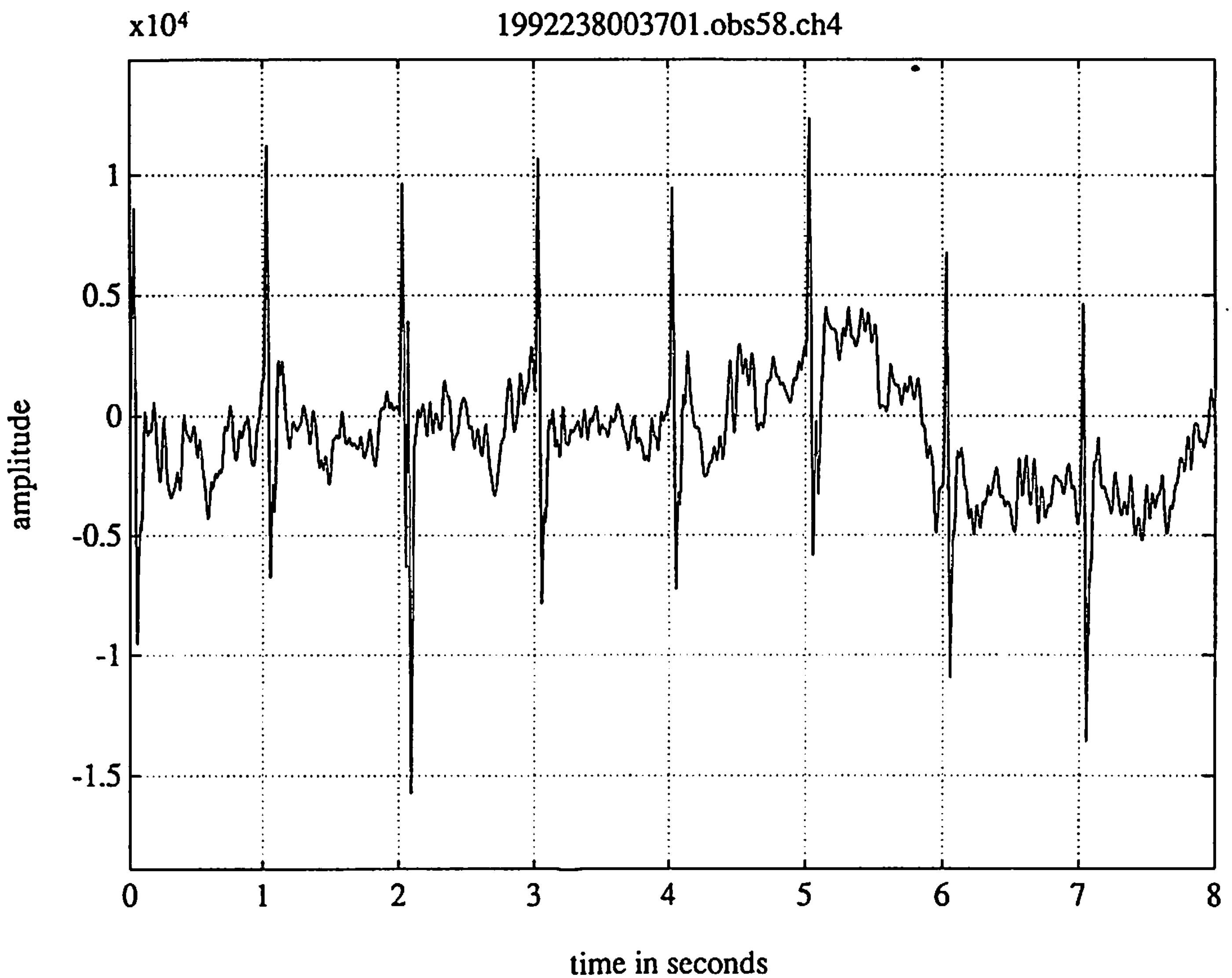


FIGURE A6.1 Hydrophone channel for OBS #58 0037Z on Day 238. Note the typical noise levels of 3000-4000 and the prominent spikes on the one second marks that are referred to throughout this report as 'GRA spikes'.

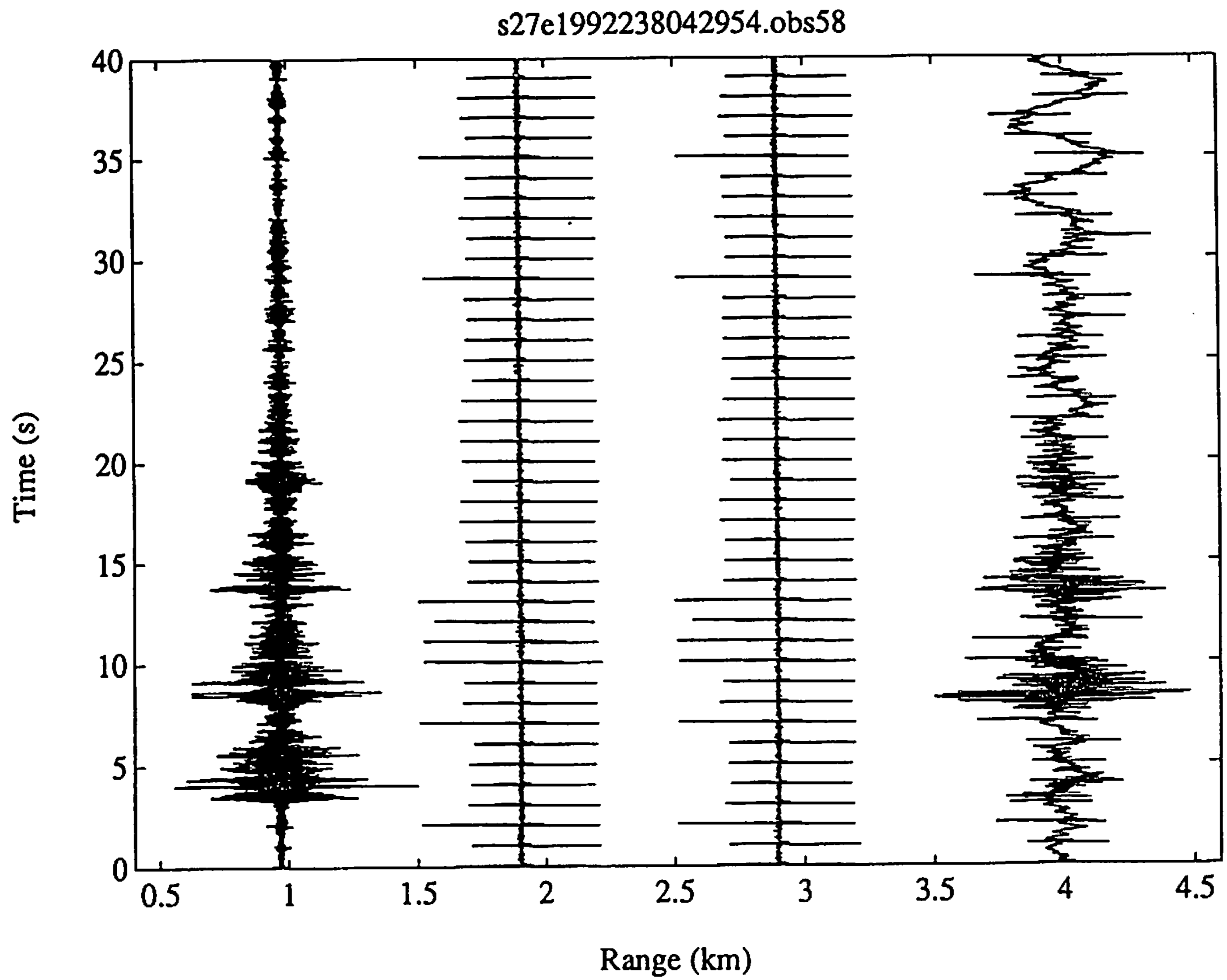


FIGURE A6.2 Records of all four channels (left to right vertical,two horizontals, hydrophone)of an event triggered by the hydrophone channel. Uncorrected first sample time was 0429:54s on Day 238. Note that the hydrophone triggered on the surface multiple above the receiver and that the record on the vertical seismometer is distinctly superior to that on the hydrophone. Both horizontal channels are against the stops and are dominated by the characteristic one second GRA spikes. Long period microseisms are clearly visible on the hydrophone channel that is also severely affected by GRA spikes.

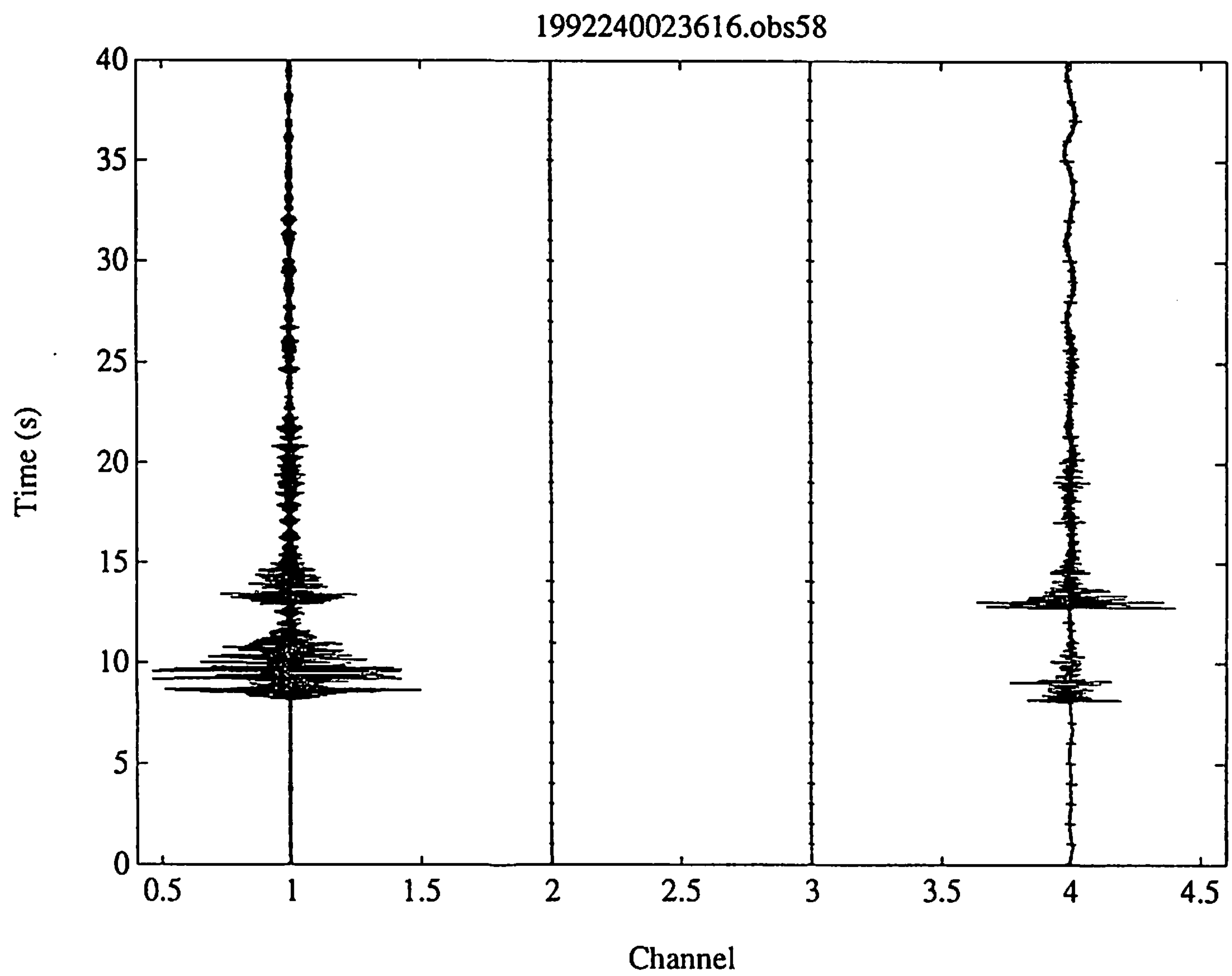


FIGURE A6.3 A larger microearthquake showing clear records on both the vertical (leftmost trace) and hydrophone (rightmost trace) channels. The two horizontal channels are off-level and are against their stops.

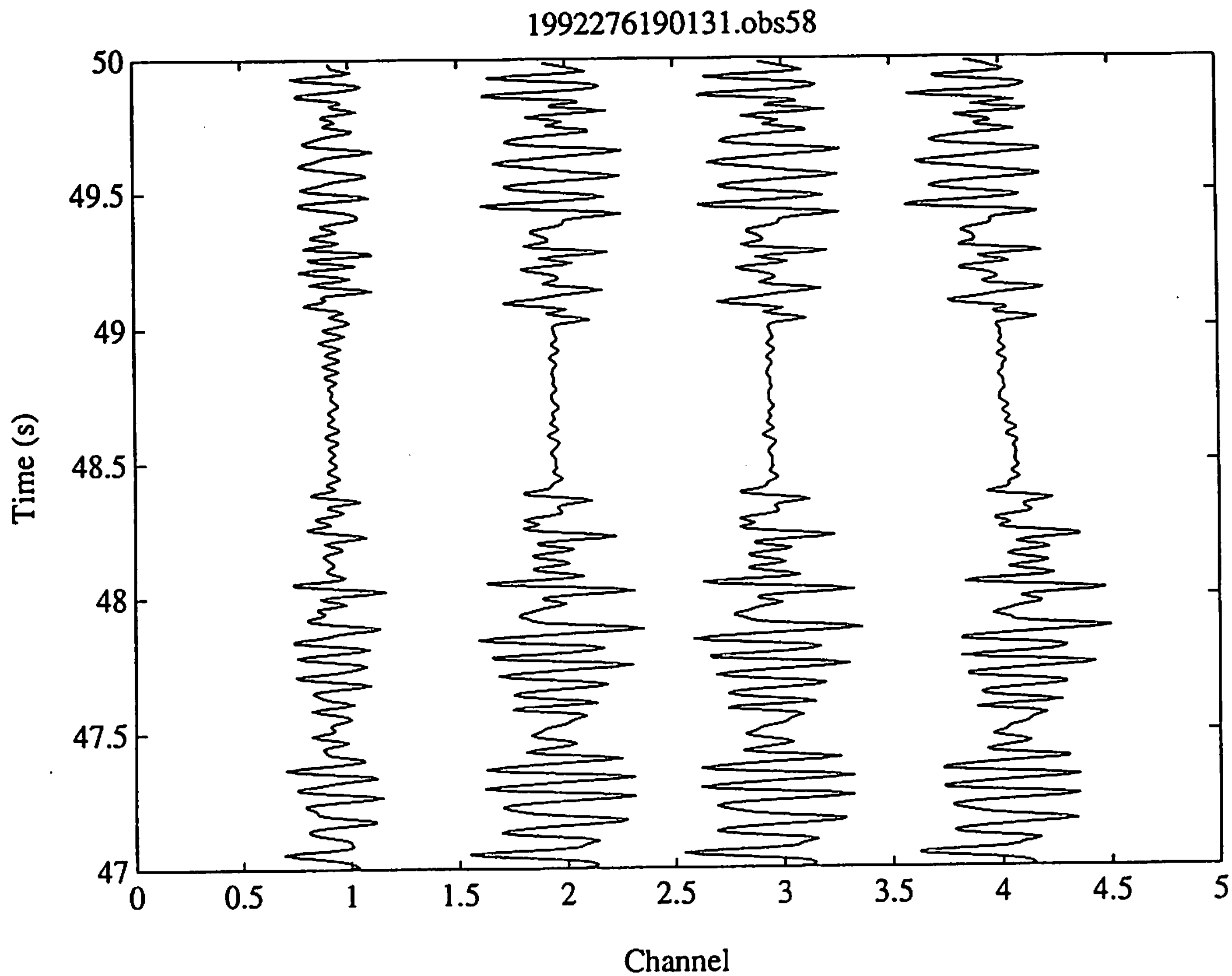


FIGURE A6.4 Three seconds of data from all four channels (vertical two horizontals and hydrophone from left to right) from the continuous recording phase on Day 276. Note two important characteristics.: the 0.6 second long segment of low amplitudes that was determined to be caused by incorrect gain information in the headers; and the considerable coherency between the hydrophone and the two horizontal channels. See text for further discussion.

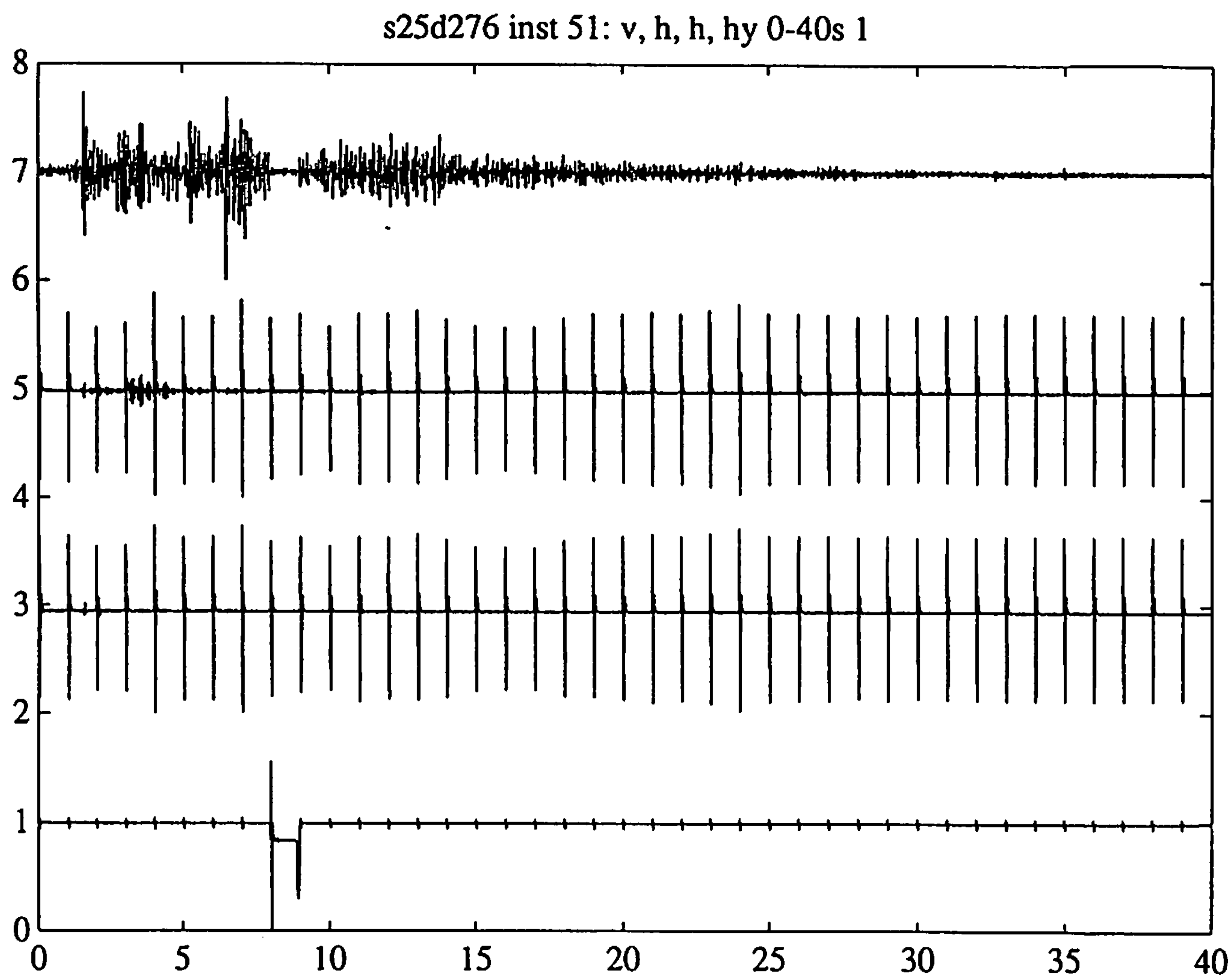


FIGURE A6.5 OBS #51 The four channels of data (vertical, horizontals, hydrophone from bottom to top). Only the hydrophone channel is useful. Note the unusual offset on the vertical channel occurring near 9-10 seconds.

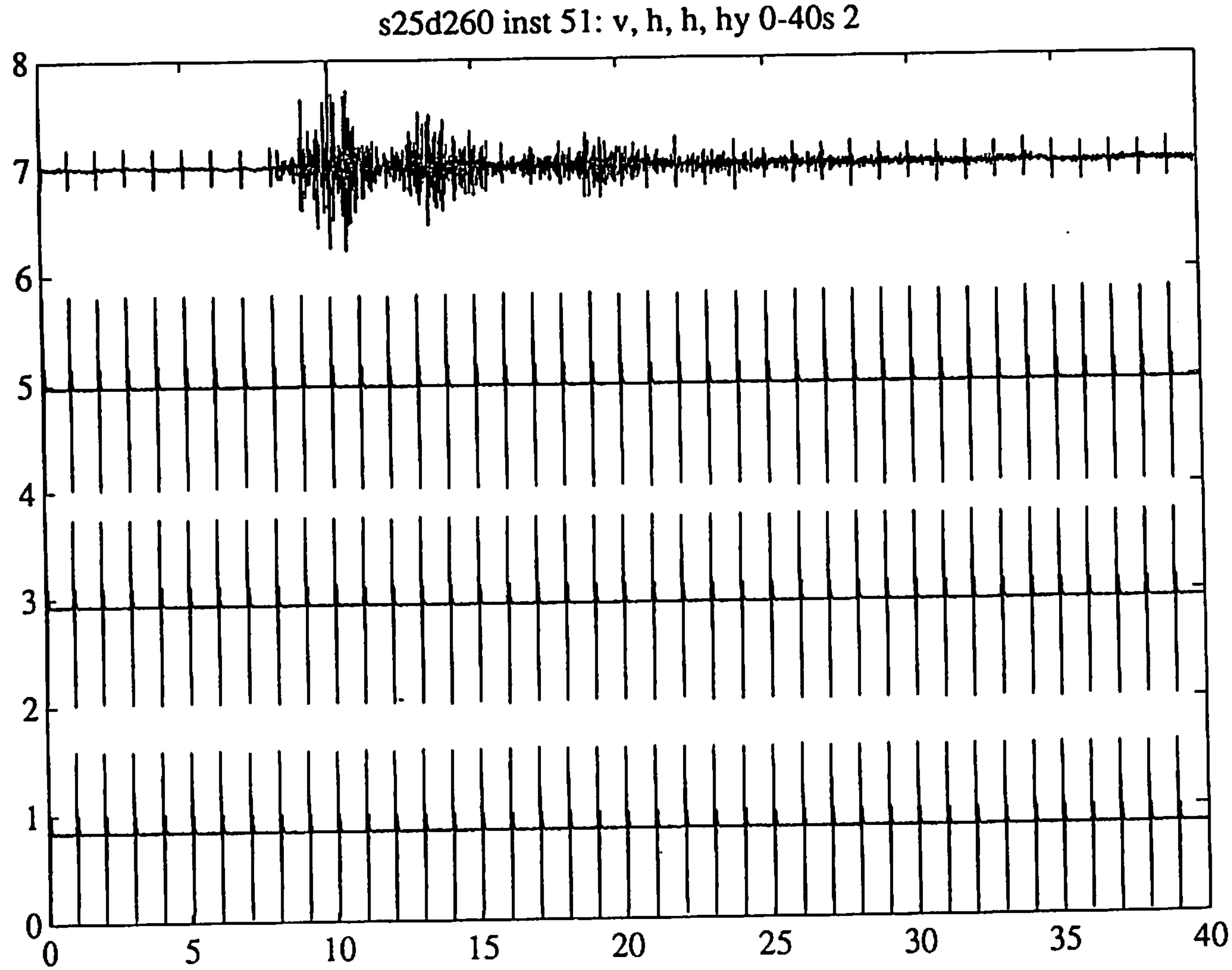


FIGURE A6.6 OBS #51 A second example that shows how the GRA spikes dominate the data: all three seismometer sensors are off-level and against their stops.

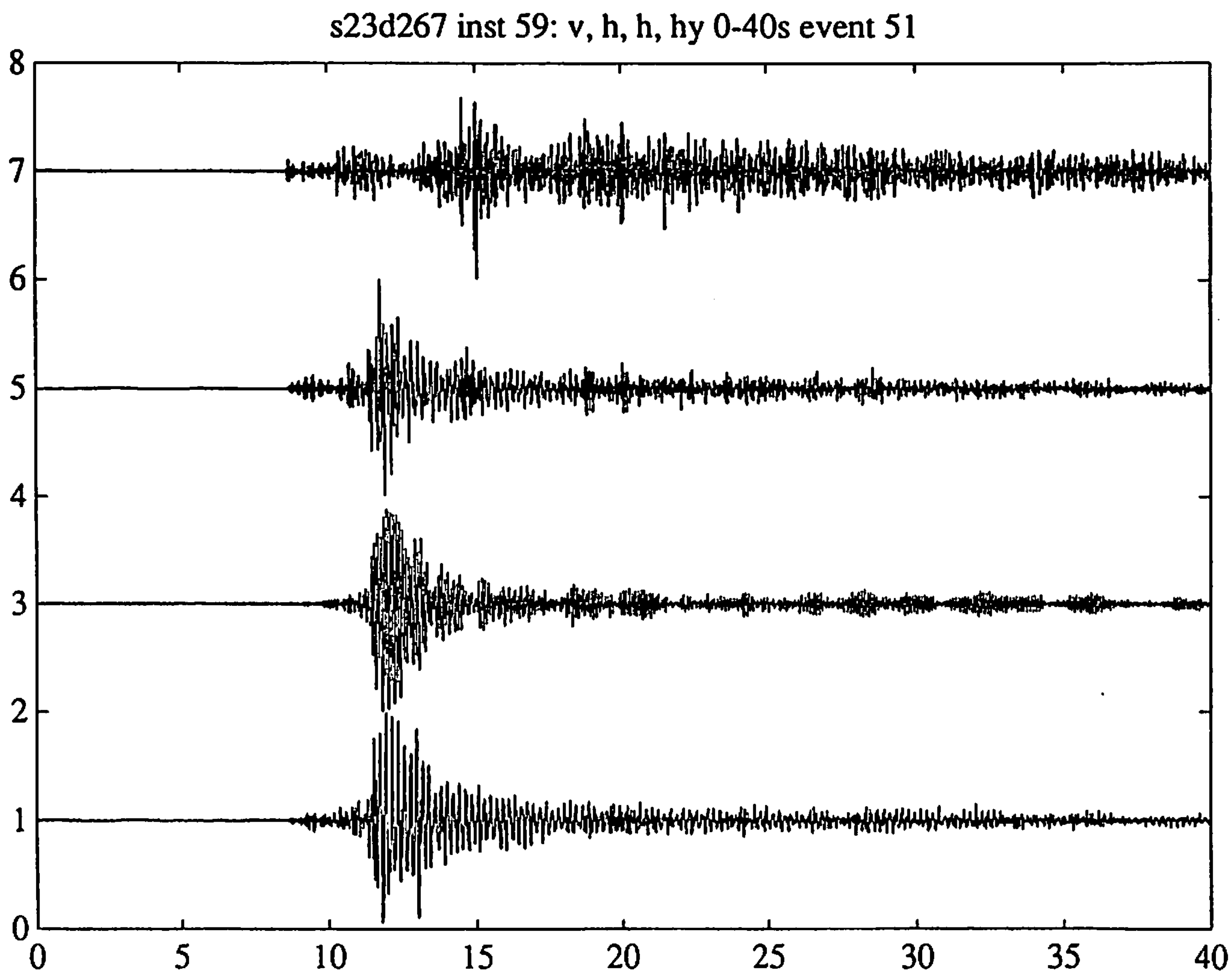


FIGURE A6.7 OBS# 59 An example of.a good event (vertical, two horizontals and the hydrophone from bottom to top) The P-S time appears to be approximately 3 seconds and the hydrophone records the water multiple well.

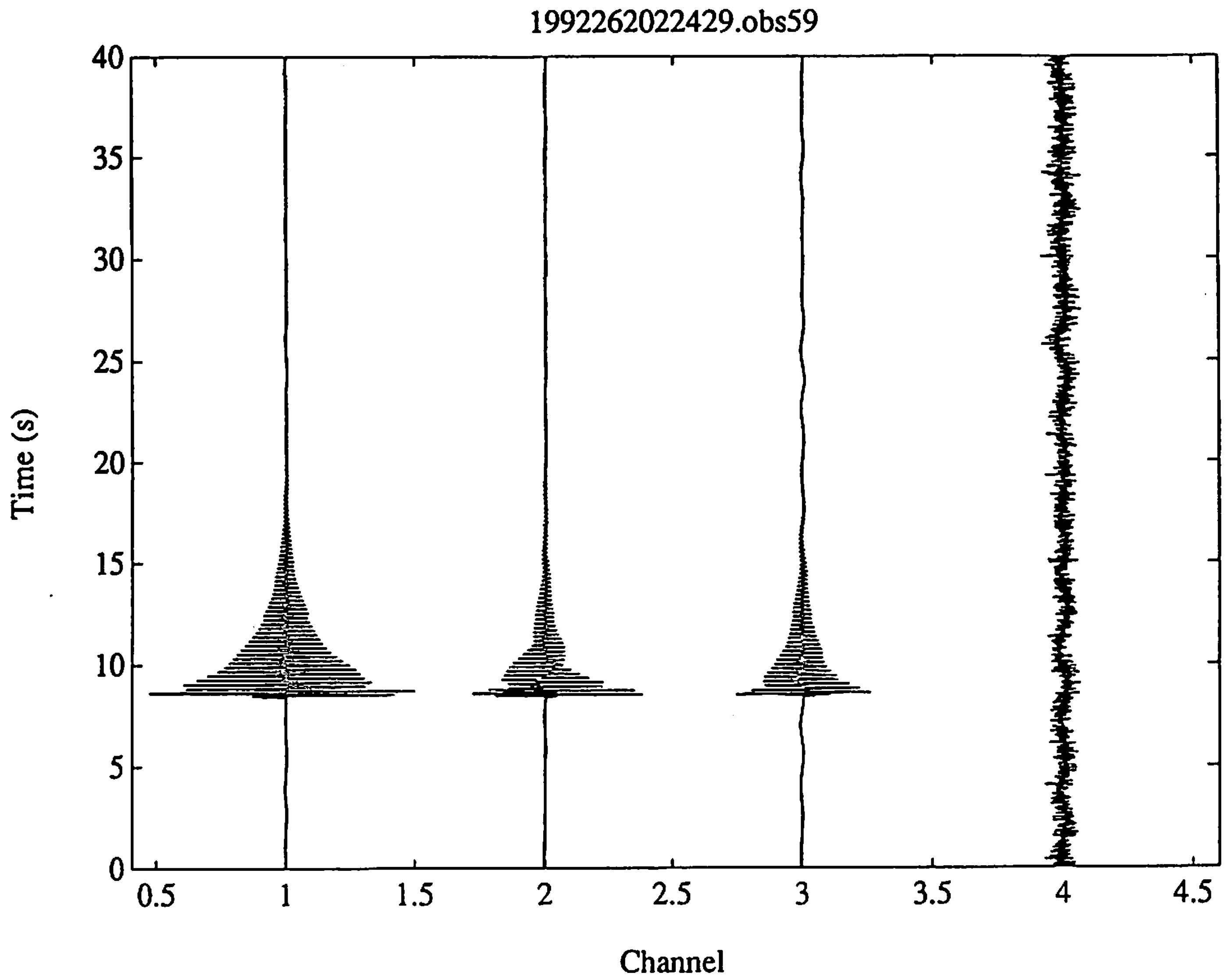


FIGURE A6.8 OBS# 59 Example of an unusual oscillatory event observed only on the seismometer channels (vertical, two horizontals, hydrophone from left to right).

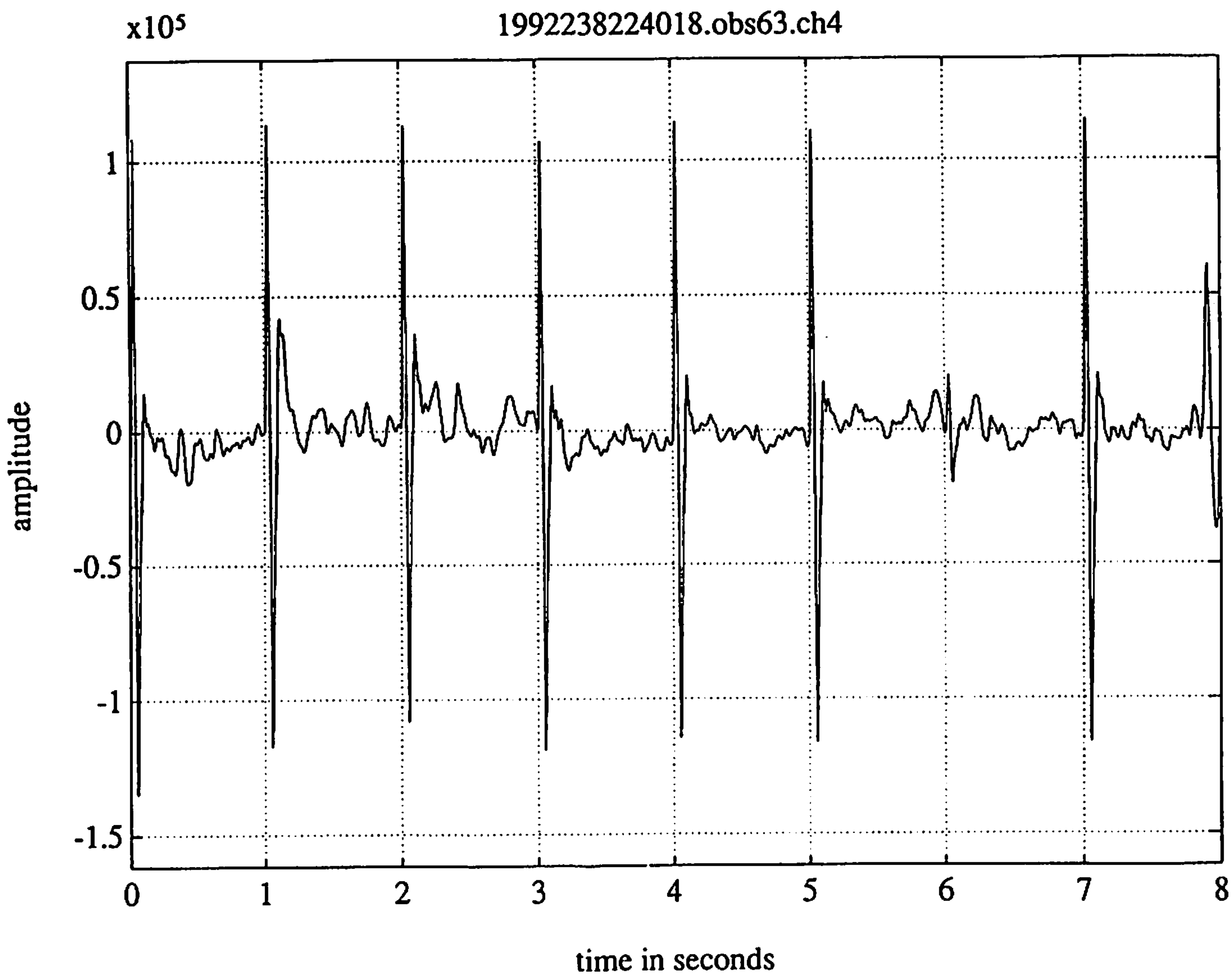


FIGURE A6.9 OBS# 63 An example of one second GRA spikes superimposed on a noisy and only partially functioning hydrophone channel.

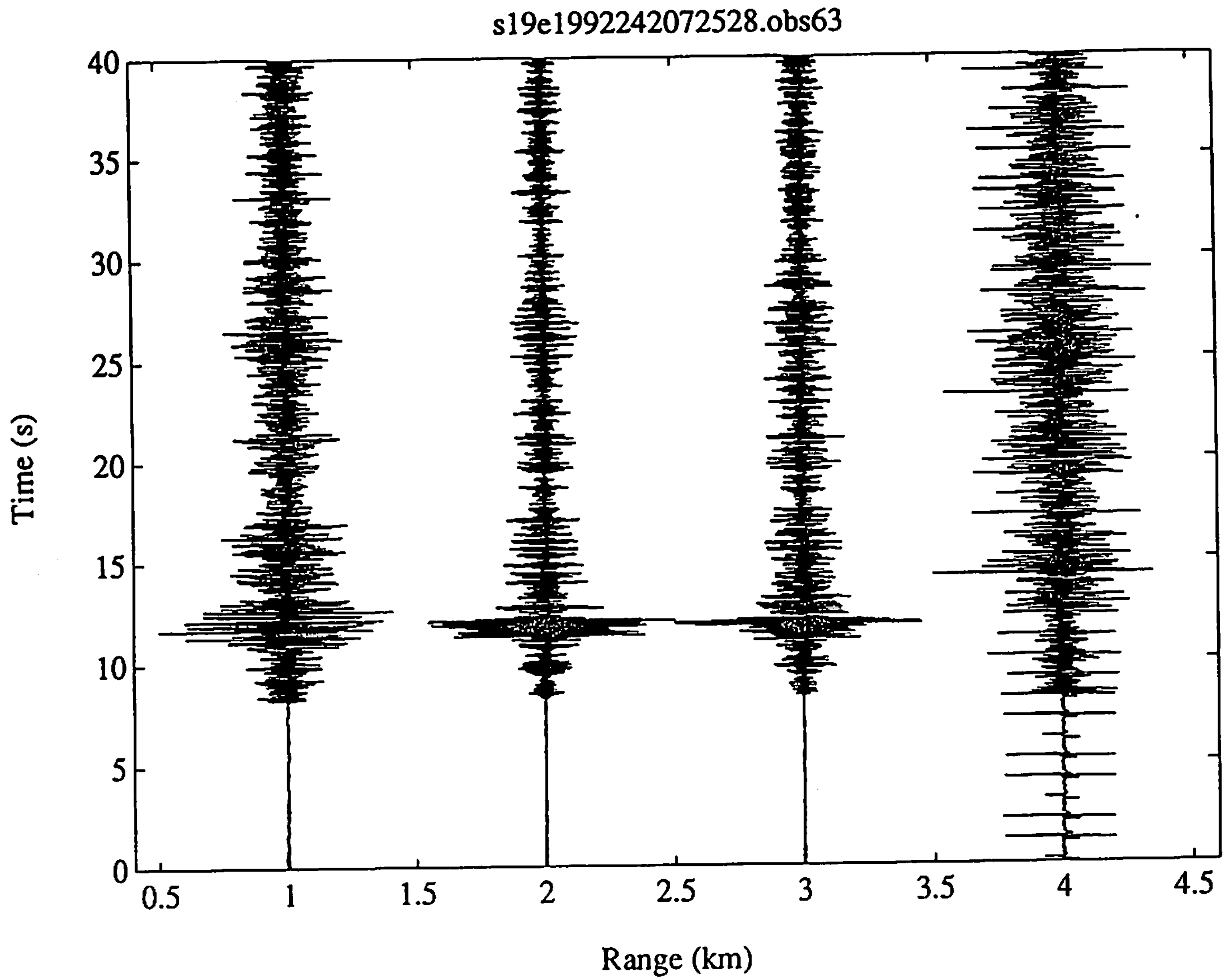


FIGURE A6.10 OBS #63 A clear microearthquake record showing good P and S wave arrivals: from left to right the channels are vertical, the two horizontals, and the hydrophone.

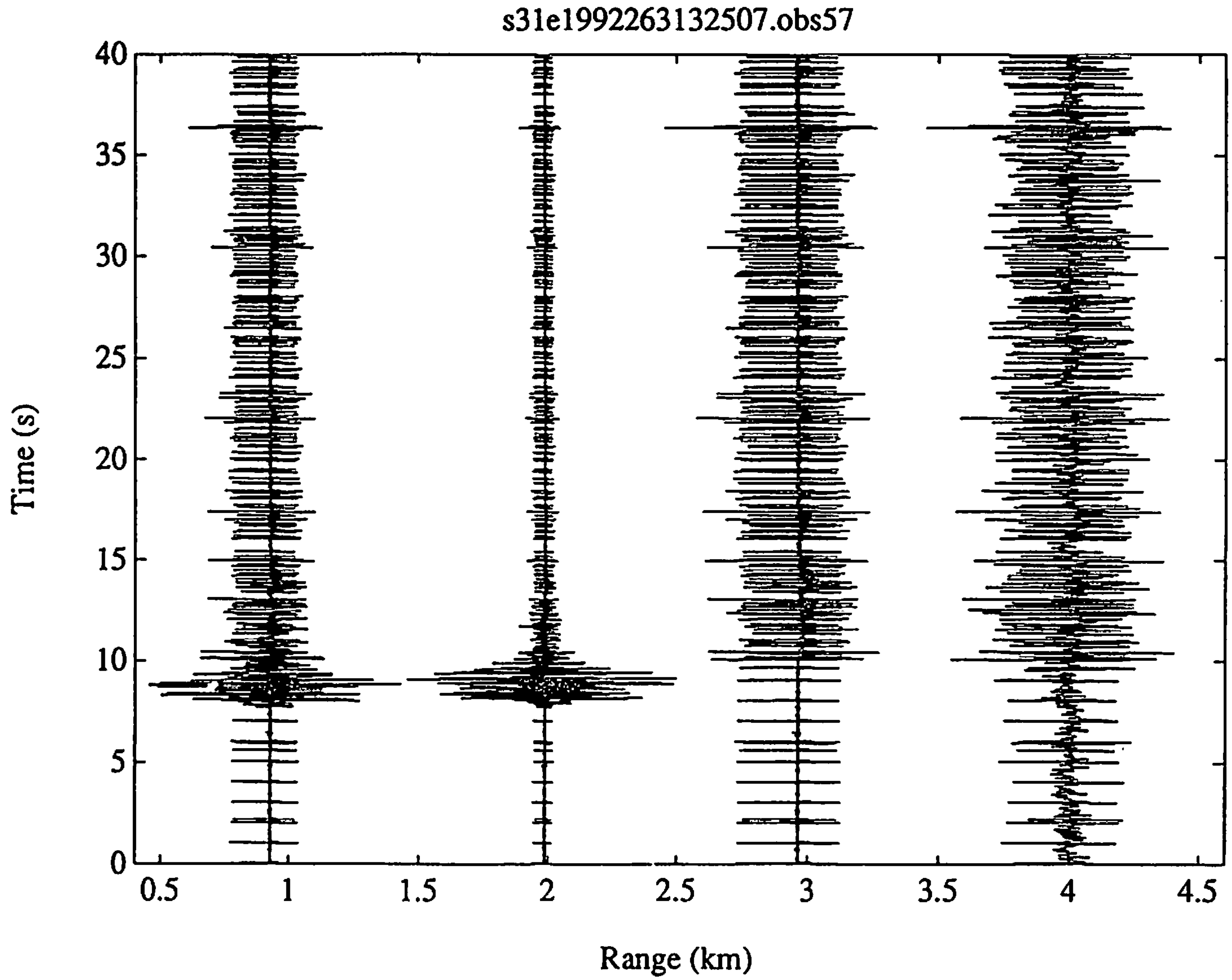


FIGURE A6.11 OBS #57 An example of closely spaced spikes effectively destroying otherwise usable data. From left to right the channels are vertical, the two horizontals and the hydrophone.

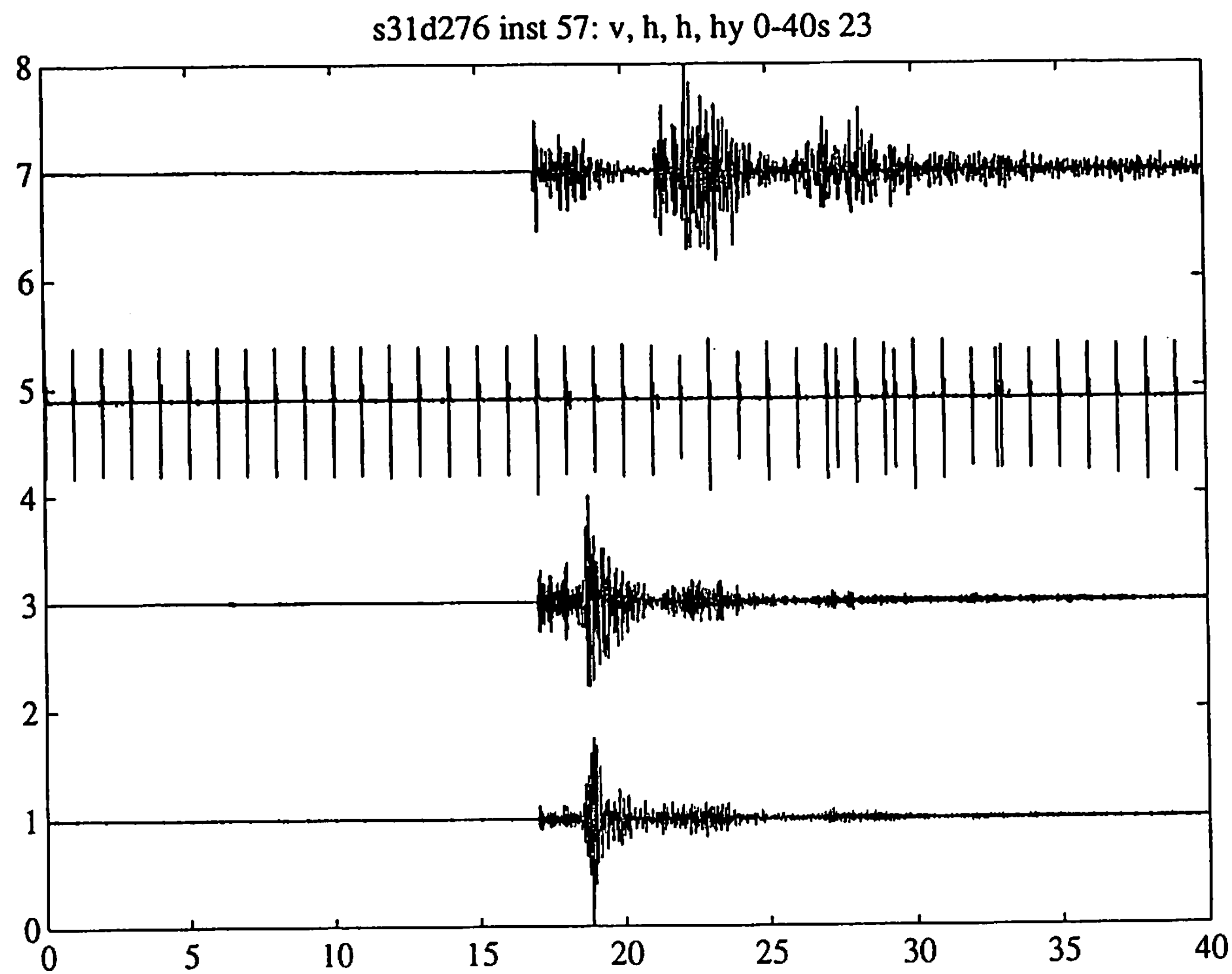


FIGURE A6.12 OBS # 57 An example of a good microearthquake event. From top to bottom the channels are hydrophone, the two horizontals and the vertical. The P-S time is approximately 2 seconds and the water multiple is clearly identifiable on the hydrophone channel.

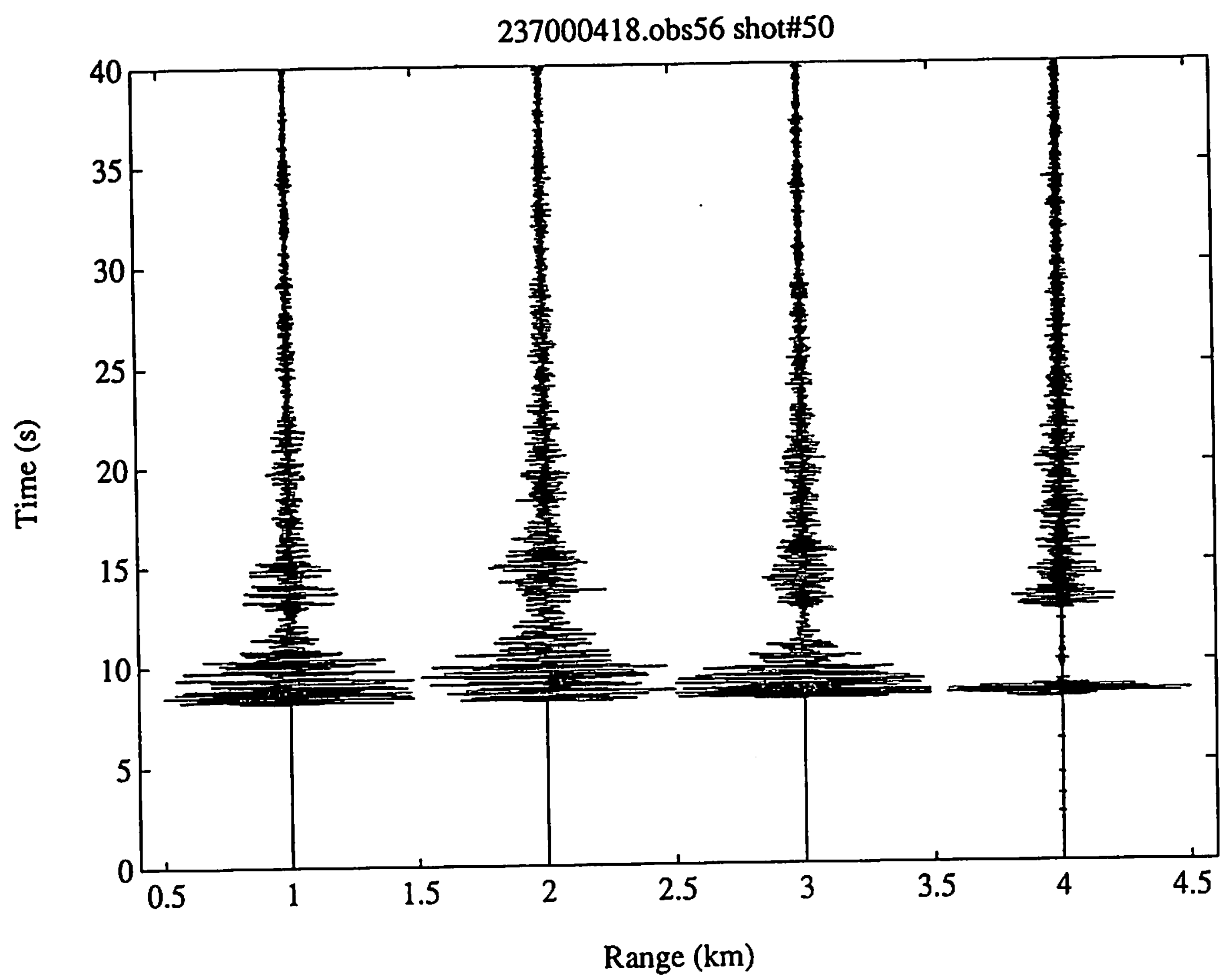


FIGURE A6.13 OBS #56 An example of a good explosive shot record for a 60 lb shot.. From left to right the channels are vertical, the two horizontals and the hydrophone. The hydrophone seems to functioning here.

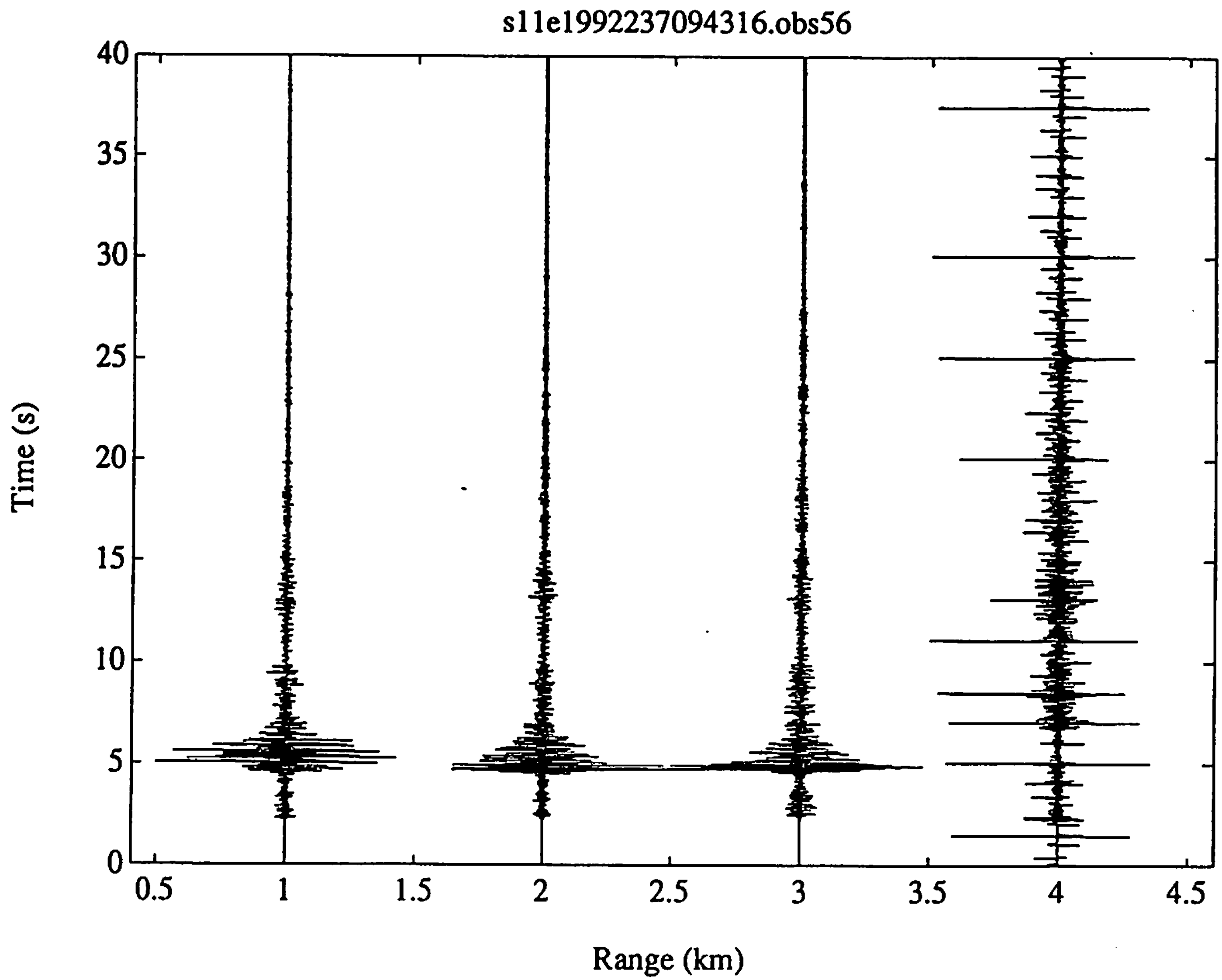


FIGURE A6.14 OBS #56 An example of a microearthquake event . The channel distribution is as in the previous figure and here even though the microearthquake is clearly identifiable on the seismometer channels it is obvious that the hydrophone is not functioning.

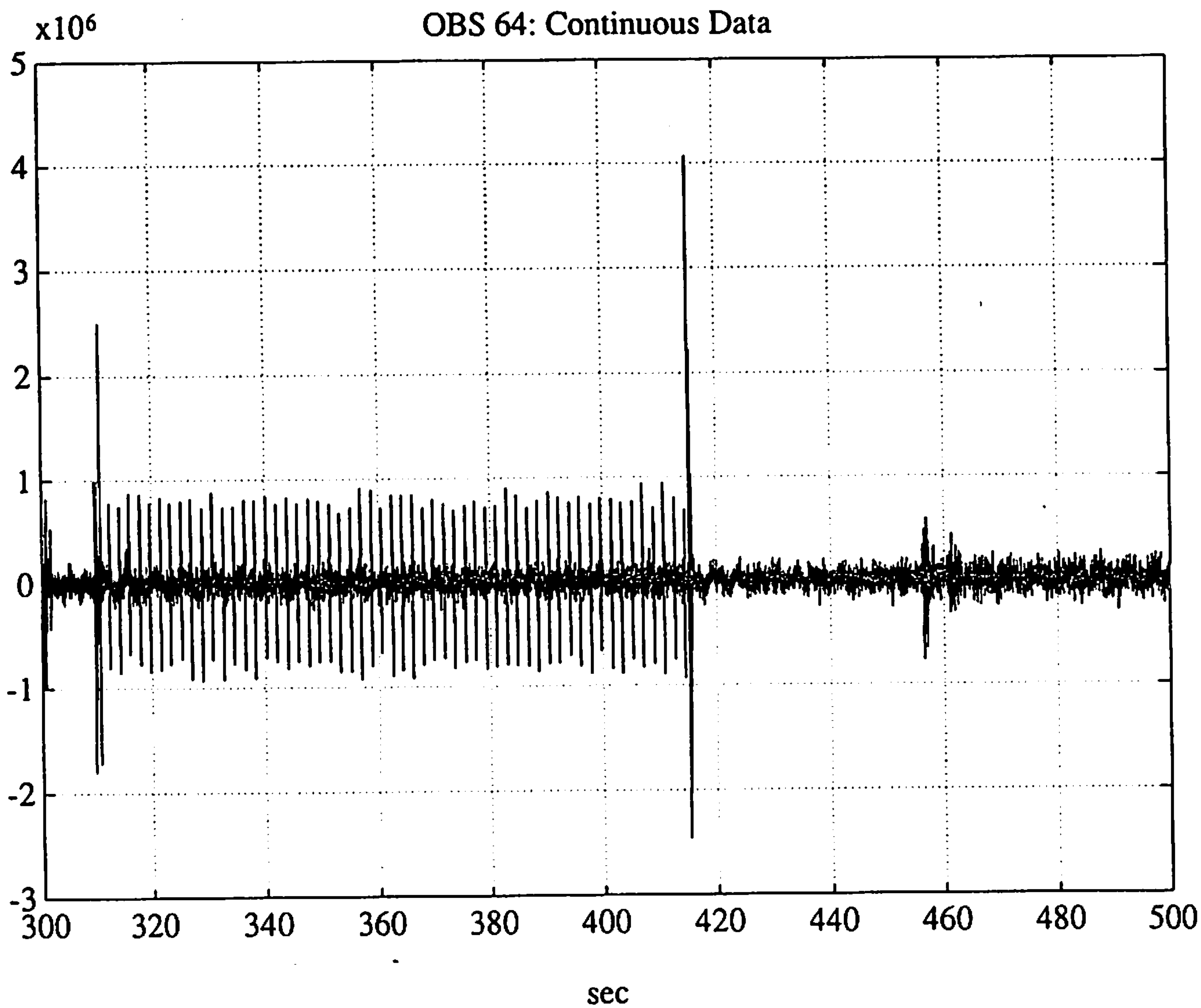


FIGURE A6.15 OBS #64 An intriguing example from the continuously recording phase of the Maxtor transients (at 310 and 415 seconds) appearing to turn on and turn off the GRA spikes.

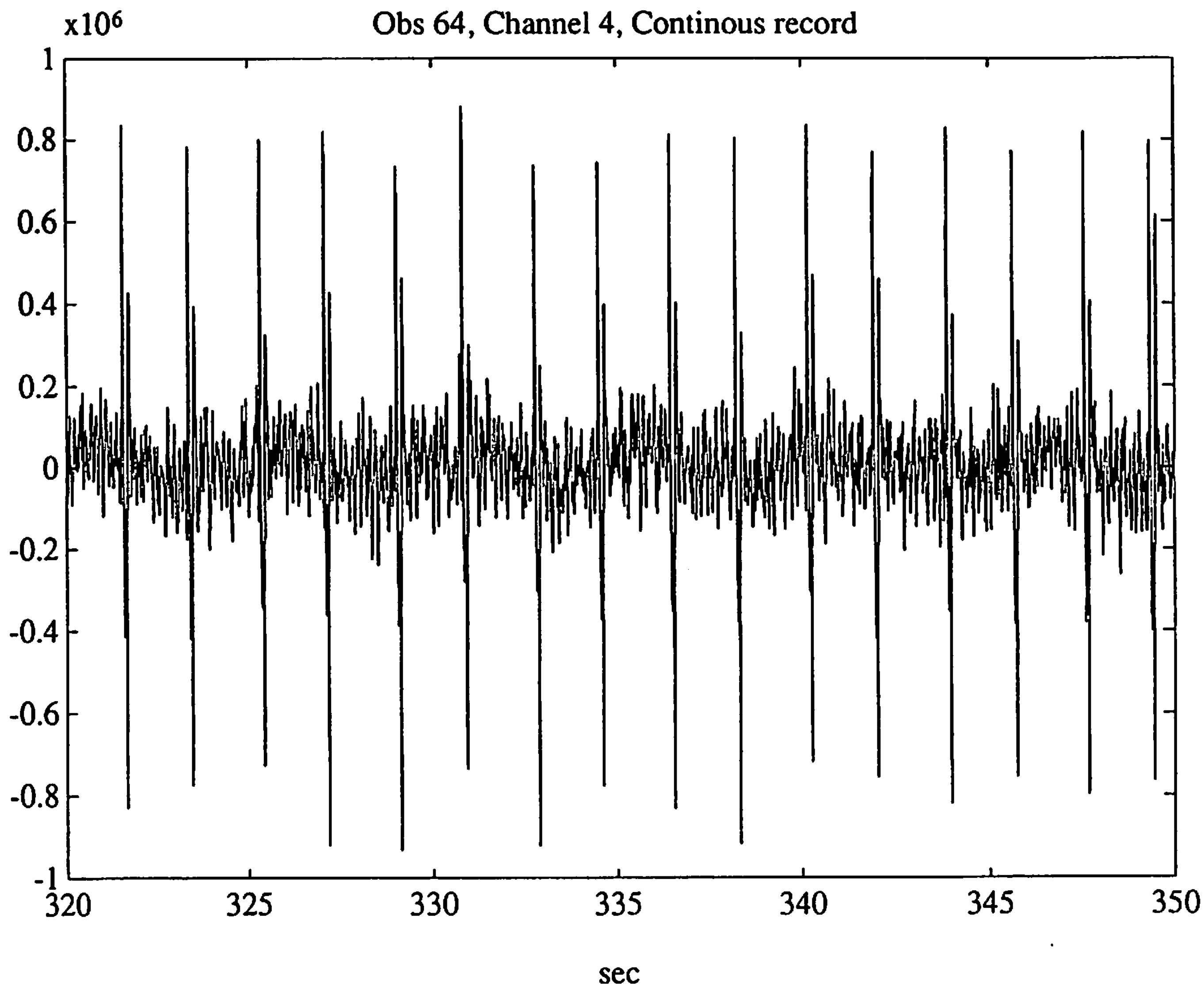


FIGURE A6.16 OBS #64 An example of one second GRA spikes on the hydrophone channel during the continuous recording phase.

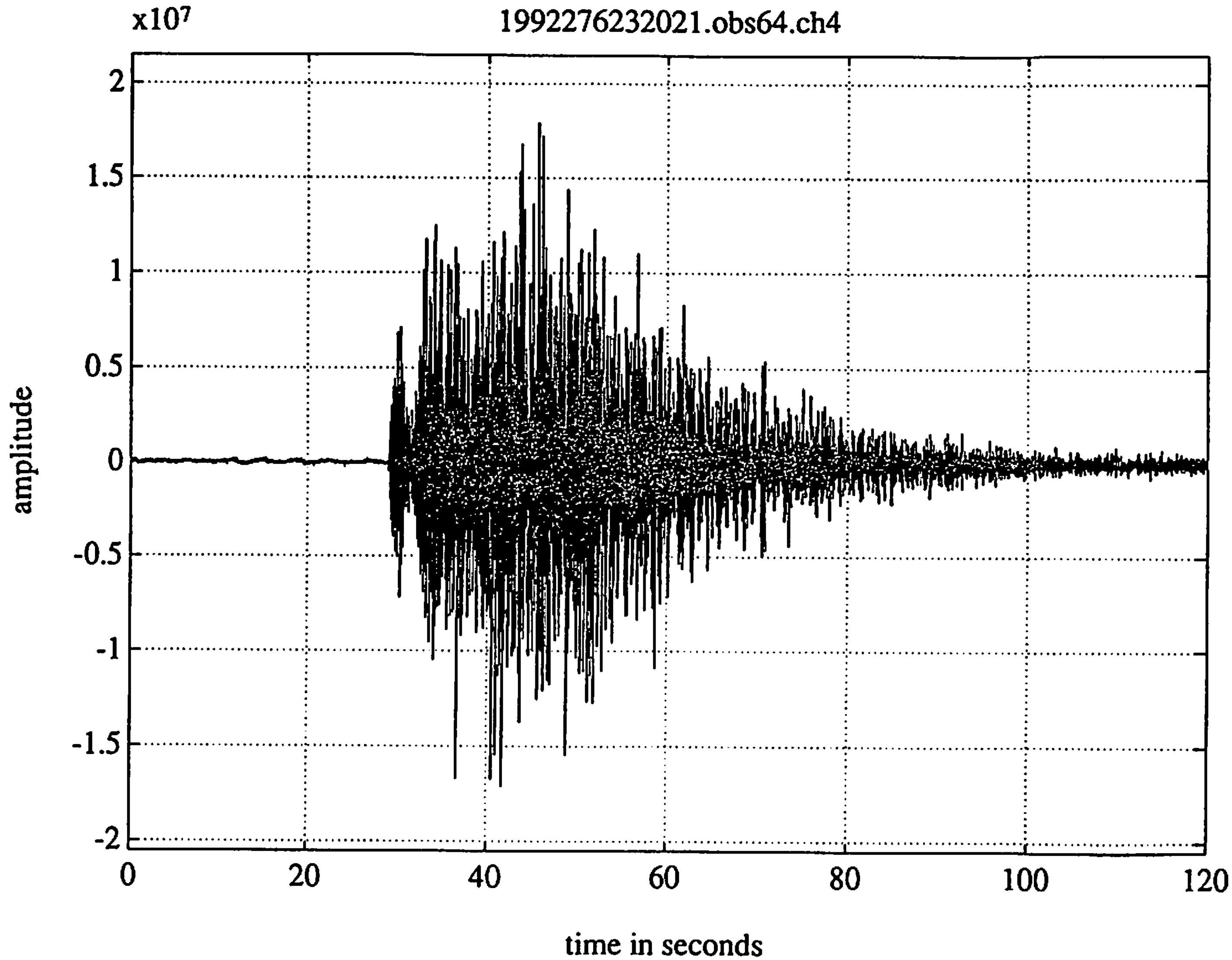


FIGURE A6.17 OBS # 64 An example of a good microearthquake event on the hydrophone channel.

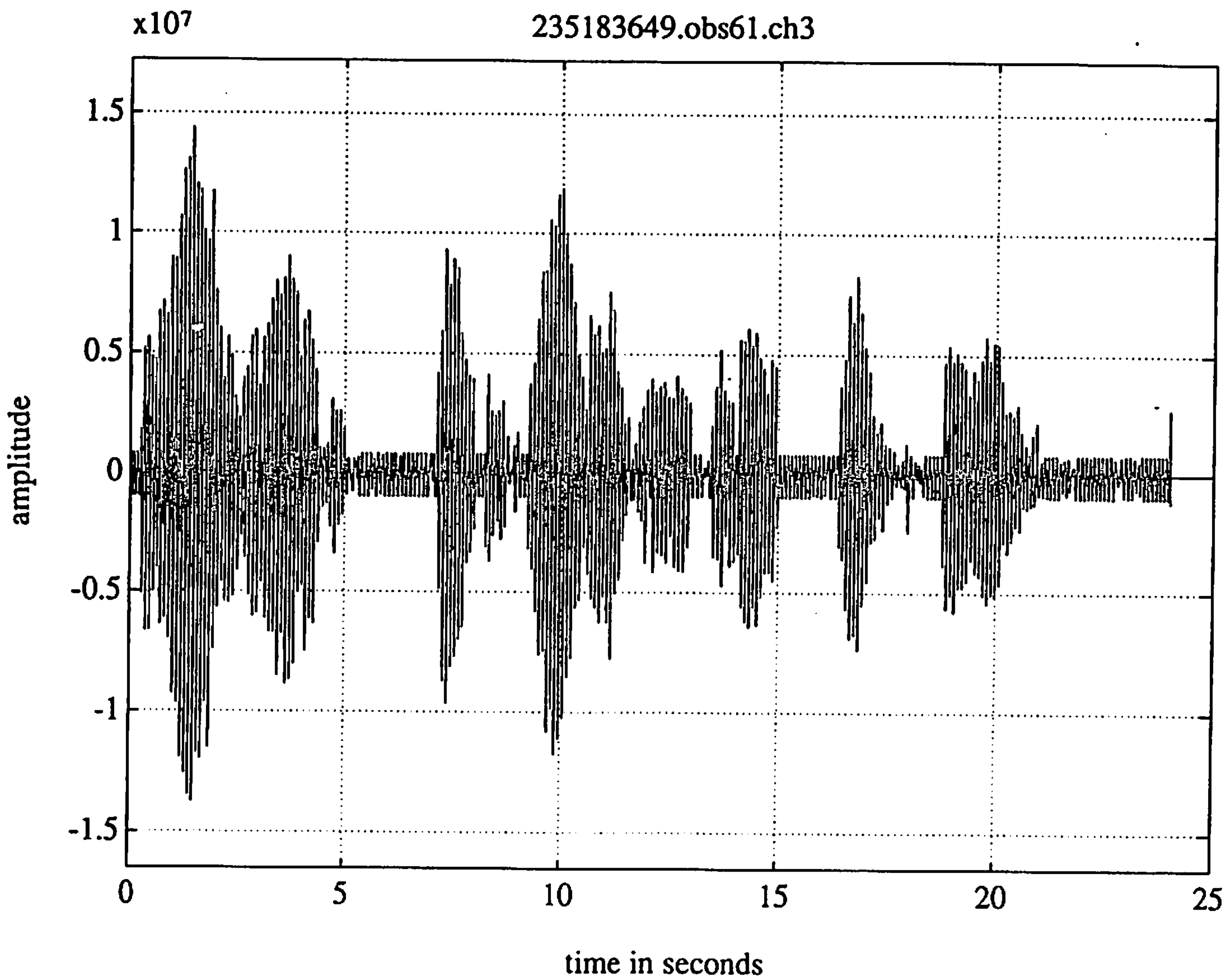


FIGURE A6.18 OBS #61 An example of the poor data recorded by one of the horizontal seismometer channels: the single level oscillatory signal is obviously bogus.

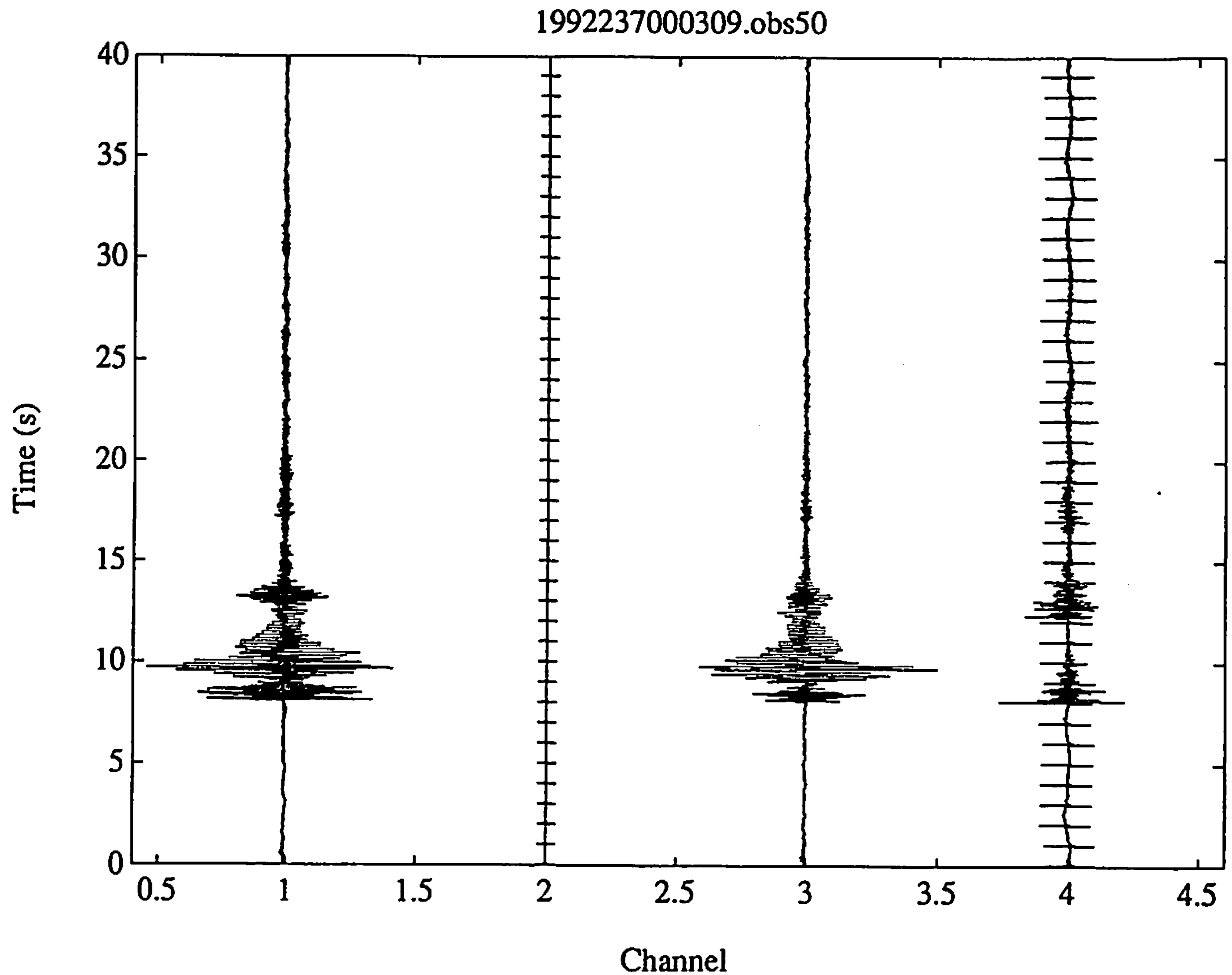


FIGURE A6.19 OBS #50 An example of a microearthquake record showing the GRA spikes spoiling an otherwise reasonable hydrophone record (the rightmost channel).

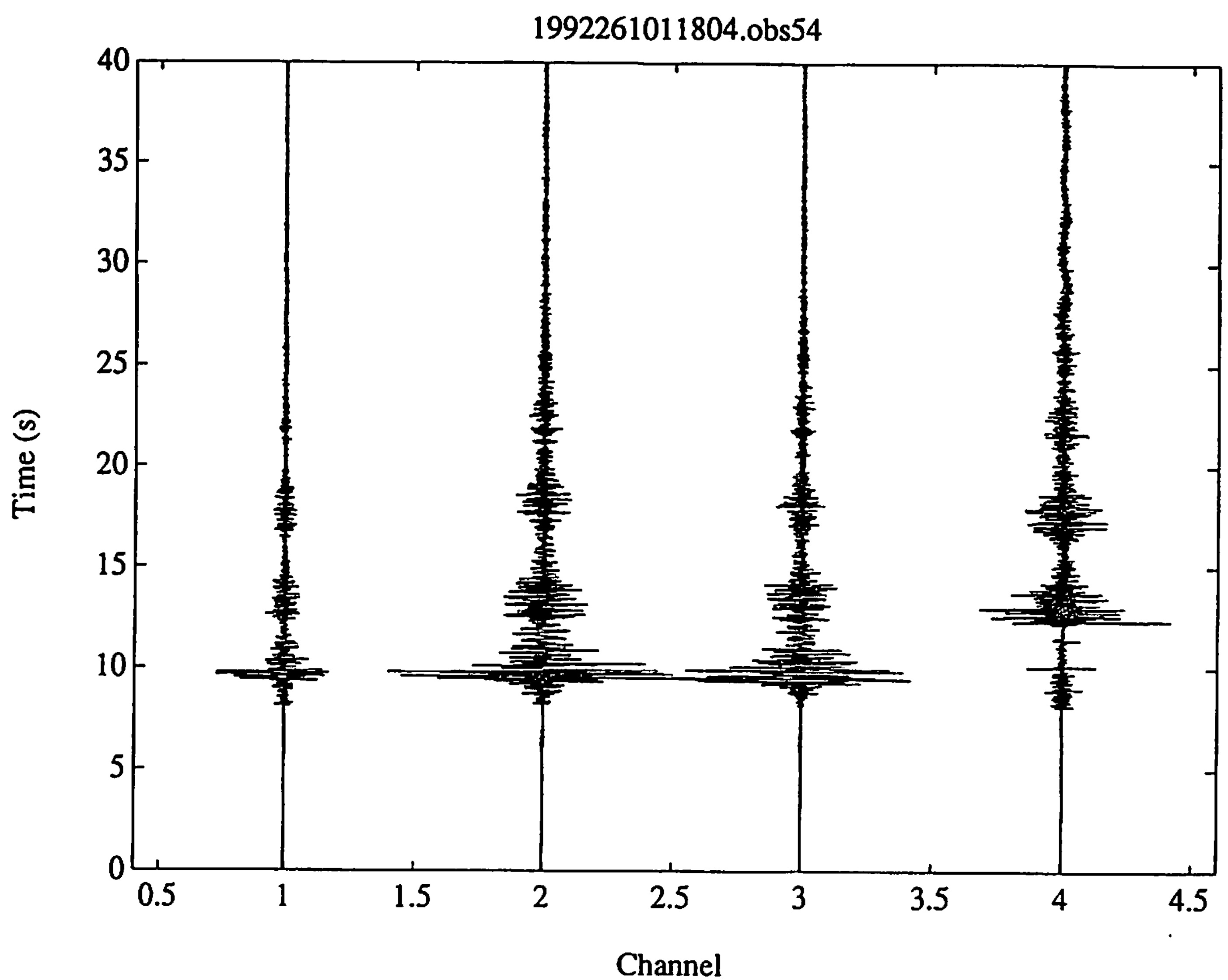


FIGURE A6.20 OBS #54 An example of a good microearthquake record with four functioning channels. The P-S time is approximately one second and the water multiple is clearly identifiable on the hydrophone record. From left to right the channels are vertical, the two horizontals and the hydrophone

Performance Tables

TABLE A6.1 OBSERVATIONS OF OBS SENSOR TILT

OBS NOS.	DATA MBYT	TILT <15	TILT 15	TILT >15	EDGE	GAP	SEDI MENT	NOT DEPL	LOCA TION	TILT DIRN	BAD BATT
62	0				X	<5	2		IF-S	AWAY	X
58	400					22.5	NA	X	IF-S	TOW.	
51	215				X	12.5	1-2		RM	TOW.	
59	400		X			12.5	0		IF-S	LT	X
53	16			X		12.5	1		IF-RM	TOW.	X
63	400				X	12.5	2		IF-RM	RT	X
57	225					5	NA	X	IF-W	TOW.	
56	336	X					0-1		IF		
52	16	X				17.5	2		IF-RM	AWAY	X
64	331				X	5	2		RM	RT	
60	0		X			20	0-1		IF-C	RT	X
61	400	X				22.5	2		RM	AWAY	X
50	0.26				X	5	0-1		IF-C	LT	X
54	400	X				5	0-1		IF-C	TOW	X
#		4	2	1	5			2			9

Table A6.1: This a compilation of data determined primarily from the RSLI's (Rust Spot Level Indicators) fitted to the sensor packages . The 12 columns present the following information:

Column 1: OBS number - see Appendix ? for precise locations.

Column 2: Volume of data recorded on the Maxtor optical disc drive. This a toal volume figure without consideration of what is good or bad or even what is readable.

Columns 3-6: Indications of tilt of the sensor package from the RSLI's. 15 degrees is the nominal maximum tilt that the gimbals can handle. "Edge" means the RSLI was off scale - the rust spot was right at the edge of the dish.

Column 7: Is the direction of tilt of the sensor package relative to the flanges on the base plate.

Column 8: Sediment recovery: 2 means a lot, 0 means none.

Column 9: Simply an indication of whether the sensor package was deployed from its arm.

Column 10: Location of the OBS on the ridge. IF-S is inner floor to the south, RM is rift mountains, IF-RM is on the edge of the innerfloor near the rift mountains.

Column 11: This gives the direction of tilt of the sensor package relative to the main instrument package. 'Away' means it was tilted away from the main package, 'Tow' means towards, 'Lt' means it was on its side to the left, 'Rt' means it was on its side to the left.

Column 12 Is the status of the 28volt battery section upon recovery. An 'X' indicates that this section of the pack (that powers the Maxtor) was dead.

TABLE A6.2: PRELIMINARY OBS PERFORMANCE ASSESSMENT

OBS NOS.	DATA MBYT	CLOK DRIFT	NO.OF EVNT	NO.OF CHAN	HYDR NOS	COMMENTS
62	0	108	0	0	G7	No data
58	400	36	5071	2	G4	Both horiz. dead Vertical OK Hydrophone OK except for 1sec spikes
51	215	18	932	0-1	1134	All seismometers bad. Very bad 1sec spikes on hydrophone but some events visible
59	400	37	7030	4	G9	Four good channels
53	16	?	?	4	1386	All seismometers OK Hydrophone reasonable. Bad Blocks
63	400	124	?	3	1140	All seismometers OK Hydrophone very poor. Bad 1second spikes.Bad Blocks.
57	225	17	1171	3	1138	Two seismometer channels OK. Some sections of hydrophone data have very bad 1 second spikes
56	336	62	4443	3-4	G6	All seismometers OK. Hydrophone gets shots but is spikey and has 1 second spikes. Bad Blocks.
52	16	30	?	0	G8	Data is garbage: looks like pre-launch deck test! Bad Blocks.
64	331	101	3641	1	1385	All seismometers bad. Hydrophone OK but for 1 second spikes. Major spike at 10 second boundary. Many false trigs
60	0	23	95	4	G1	All seismometers OK. Hydrophone OK. Why is August data in recorder memory?
61	400	38	7219	3	1136	All seismometers OK Hydrophone is bad: weird trace and 1 second spikes. Missing bytes.
50	0.26	45	102	2-3	G3	Vertical and one horiz OK Shots OK on hydrophone. 1 second spikes. Serial link problem?
54	400	32	5789	3	1ST	All seismometers OK Hydrophone very glitchy.

TABLE A6.3 REQUIRED CORRECTIVE ACTIONS

OBS NOS.	Post FARA.01 ACTIONS REQUIRED October 10th 1992
62	Carry out full 16 Mb test - Cecily check results
58	Cecily check continuous recording section. Generic GRA spike problem.
51	Check seismometer package and seismometer front-end. Check hydrophone electronics. Replace hydrophone sensor. Generic GRA spike problem.
59	No action required.
53	Carry out full 16 Mb test- Cecily check results. Bad blocks. Cecily check dates on the data in the Recorder memory.
63	Multiple bad blocks. Carry out full 16 Mb test- Cecily check results. Check hydrophone electronics. Replace hydrophone sensor. Generic GRA spike problem.
57	No action required - slightly noisier than normal hydrophone. Generic GRA spike problem.
56	Bad blocks - Cecily look past bad blocks. Check hydrophone electronics and replace hydrophone sensor.No evidence of tilt so more testing of the Maxtor is appropriate.
52	Mostly bad blocks. Carry out full 16 Mb test - Cecily check the results.
64	Check sensor package and seismometer electronics. Spike at ten second boundary - why? Generic GRA spike problem.
60	Determine why August Data was in the recorder memory upon recovery.Carry out full 16 Mb test - Cecily check results.
61	Check hydrophone electronics and replace hydrophone sensor. Check sensor package and seismometer electronics. Why missing byte? Generic GRA spike problem.
50	Check for serial link problem. Carry out full 16Mb test - Cecily check results. Generic GRA spike problem.
54	Check hydrophone electronics and replace hydrophone sensor.

FARA 01 Clock Drift Corrections

The ONR OBS instruments were checked at the programming computer immediately after the instruments were brought on board at the starboard waist recovery station of the Ewing. These time captures of BIGTIME and Seascan time are compared to the BIGTIME and Seascan time captures taken during deployment of the ONR OBS instruments to determine the drift that occurred in each instrument during the deployment. The sign conventions described in appendix 14 of the FARA 01 Cruise Report are preserved in these calculations. Despite tracking the clock drifts for a month prior to deployment the Seascan clocks seem to have drifted well beyond the 1 ms per week specification that we believe is the published spec. of the Seascan clock.

It is encouraging to note, however, that no Bigtime interrupts were lost on any of the instruments during the deployment.

OBS No.		Deployment	SAIL Correction	Recovery	SAIL Correction	Change in Bigtime While Deployed	Change in Seascan While Deployed
	SAIL @	0234 11:26:16.981259	-0.000496	0278 15:13:43.872369	-0.000198		
	Bigtime	714396377		718211624			
#62	Delta	-0.018741		-0.127631		-0.108592	
	SAIL @	0234 11:26:37.999829	-0.000496	0278 15:16:43.890924	-0.000198		
	Seascan#30	0234 11 26 38		0278 15 16 44			
	Delta	-0.000171		-0.109076			-0.108607
	SAIL @	0234 10:45:12.981572	-0.000496	0278 17:22:30.945216	-0.000203		
	Bigtime	714393913		718219341			
#58	Delta	-0.018428		-0.054784		-0.036063	
	SAIL Clock @	0234 10:45:39.999870	-0.000496	0278 17:25:01.963526	-0.000203		
	Seascan #46	0234 10 45 40		0278 17 25 02			
	Delta	-0.000130		-0.036474			-0.036051
	SAIL Clock @	0234 14:49:59.985472	-0.000505	0278 19:49:54.967533	-0.000207		
	Bigtime	714408600		718228195			
#51	Delta	-0.014528		-0.032467		-0.017641	
	SAIL Clock @	0234 14:50:24.004000	-0.000505	0278 19:50:45.986068	-0.000207		
	Seascan #39	0234 14 50 24		0278 19 50 46			
	Delta	+0.004000		-0.013932			-0.017634
	SAIL Clock @	0234 13:49:39.979026	-0.000503	0278 22:00:27.941876	-0.000212		
	Bigtime	714404980		718236028			
#59	Delta	-0.020974		-0.058124		-0.036859	
	SAIL Clock @	0234 13:50:06.997547	-0.000503	0278 22:02:24.960407	-0.000212		
	Seascan #18	0234 13 50 07		0278 22 02 25			
	Delta	-0.002453		-0.039593			-0.036849

	SAIL Clock @			0279 00:19:06.936547	-0.000216		
	Bigtime	time lost		718244347			
#53	Delta			-0.063453		N. A,	
	SAIL Clock @	0230 12:56:55.000121		0279 00:21:18.951206	-0.000216		
	Seascan #31	0230 12 56 55		0279 00 21 19			
	Delta	+0.000121		-0.048794			(-0.048915
	SAIL Clock @	0234 15:53:38.981532	-0.000506	0279 02:41:09.105724	-0.000222		
	Bigtime	714412419		718252869			
#63	Delta	-0.018468		+0.105724		+0.12447 6	
	SAIL Clock @	0234 15:54:01.000064	-0.000506	0279 02:41:57.124264	-0.000222		
	Seascan #41	0234 15 54 01		0279 02 41 57			
	Delta	+0.000064		+0.124264			+0.124484
	SAIL Clock @	0234 17:00:27.985446	-0.000506	0279 04:52:50.967910	-0.000227		
	Bigtime	714416428		718260771			
#57	Delta	-0.014554		-0.032090		-0.017257	
	SAIL Clock @	0234 17:00:49.000067	-0.000506	0279 04:54:20.982541	-0.000227		
	Seascan #51	0234 17 00 49		0279 04 54 21			
	Delta	+0.000067		-0.017459			-0.017247
	SAIL Clock @	0234 17:58:26.973655	-0.000215	0279 12:31:53.912137	-0.000242		
	Bigtime	714419907		718288314			
#56	Delta	-0.026345		-0.087863		-0.061545	
	SAIL Clock @	0234 17:58:47.991914	-0.000215	0279 12:32:40.930399	-0.000242		
	Seascan #32	0234 17 58 48		0279 12 32 41			
	Delta	-0.008086		-0.069601			-0.061542
	SAIL Clock @	0234 18:36:16.979373	-0.000385	0279 14:31:45.948958	-0.000246		
	Bigtime	714422177		718295506			
#52	Delta	-0.020627		-0.051042		-0.030272	
	SAIL Clock @	0234 18:36:40.997910	-0.000385	0279 14:33:15.967509	-0.000246		
	Seascan #34	0234 18 36 41		0279 14 33 16			
	Delta	-0.002090		-0.032491			-0.030262
	SAIL Clock @	0234 20:48:47.985363	-0.000497	0279 17:40:41.883709	-0.000252		
	Bigtime	714430128		718306842			
#64	Delta	-0.014637		-0.116291		-0.101409	
	SAIL Clock @	0234 20:49:11.999984	-0.000497	0279 17:42:08.898336	-0.000252		
	Seascan #27	0234 20 49 12		0279 17 42 09			

	Delta	-0.000016		-0.101664			-0.101403
	SAIL Clock @	235 13:00:31.979586	-0.000521	279 19:44:11.956506	-0.000257		
	Bigtime	714488432		718314252			
#60	Delta	-0.020414		-0.043494		-0.022816	
	SAIL Clock @	235 13:01:17.998116	-0.000521	279 19:45:44.975038	-0.000257		
	Seascan #29	235 13 01 18		279 19 45 45			
	Delta	-0.001884		-0.024962			-0.022814
	SAIL Clock @	0235 13:29:12.978459	-0.000522	0279 22:44:12.940387	-0.000263		
	Bigtime	714490153		718325053			
#61	Delta	-0.021541		-0.059613		-0.037813	
	SAIL Clock @	0235 13:29:37.996998	-0.000522	0279 22:45:47.958916	-0.000263		
	Seascan #17	0235 13 29 38		0279 22 45 48			
	Delta	-0.003002		-0.041084			-0.037823
	SAIL Clock @	0235 14:35:09.985351	-0.000525	0280 01:09:54.940327	-0.000267		
	Bigtime	714494110		718333795			
#50	Delta	-0.014649		-0.059673		-0.044766	
	SAIL Clock @	0235 14:35:48.999988	-0.000525	0280 01:10:21.954962	-0.000267		
	Seascan #28	0235 14 35 49		0280 01 10 22			
	Delta	-0.000012		-0.045038			-0.044768
	SAIL Clock @	0235 15:40:52.985111	-0.000414	0280 03:17:00.953265	-0.000273		
	Bigtime	714498053		718341421			
#54	Delta	-0.014889		-0.046735		-0.031705	
	SAIL Clock @	0235 15:41:15.999760	-0.000414	0280 03:18:36.967912	-0.000273		
	Seascan #37	0235 15 41 16		0280 03 18 37			
	Delta	-0.000240		-0.032088			-0.031707

FARA 02 OBS Pre-Deployment Clock Checks

After reviewing the performance of the Seascan clocks during the FARA 01 deployment it was decided to reset all the clocks to zero offset relative to the GPS - SAIL Clock reference. The resets were done using the SAIL connection to the Seascan clocks over the ONR OBS Control Loop with all 14 instruments on line at once. The drift rates of four of the instruments, 56, 62, 63 and 64, were also adjusted. The clock times were checked at the programming station as part of the normal deployment procedure. For each measurement, the offset of the SAIL clock against GPS was also recorded. The sign conventions described in appendix 14 of the FARA 01 Cruise Report are preserved in the calculations. The Table below presents the results of the FARA 02 Deployment checks. The offset of BIGTIME and the Seascan clocks, as in FARA 01, are either approximately 14 ms or 18 ms.

OBS #		SAIL Clock Captures	Bigtime Corr. milli sec	Seascan Corr. milli sec	SAIL Clock	SAIL Corr. milli sec	Net Corr. milli sec
	SAIL	0304 23:58:09.981526	-18.474			-19.163	
	@ Bigt	720489490					
50	CK28				0304 23:59:11.000689	-0.689	-18.539
	SAIL	0304 23:59:00.000065		+0.065		-0.624	
	@ Seas	0304 23 59 00					
	SAIL	0305 13:35:11.985714	-14.286			-15.004	
	@ Bigt	720538512					
51	CK39				0305 13:36:18.000718	-0.718	-14.621
	SAIL	0305 13:35:58.000335		+0.335		-0.383	
	@ Seas	0305 13 35 58					
	SAIL	0304 23:09:12.981602	-18.398			-19.085	
	@ Bigt	720486553					
52	CK34				0304 23:10:26.000687	-0.687	-18.398
	SAIL	0304 23:10:08.000143		+0.143		-0.544	
	@ Seas	0304 23 10 08					
	SAIL	0304 21:50:30.981445	-18.555			-19.239	
	@ Bigt	720481831					
53	CK31				0304 21:52:54.000684	-0.684	-18.567
	SAIL	0304 21:52:38.000012		+0.012		-0.672	
	@ Seas	0304 21 52 38					
	SAIL	0304 20:18:48.985352	-14.648			-15.329	
	@ Bigt	720476329					
54	CK37				0304 20:20:04.000681	-0.681	-14.652
	SAIL	0304 20:19:47.000004		+0.004		-0.677	
	@ Seas	0304 20 19 47					

	SAIL	0304 22:45:50.981991	-18.009			-18.694	
	@ Bigt	720485151					
56	CK32				0304 22:46:54.000685	-0.685	-18.262
	SAIL	0304 22:46:42.000253		+0.253		-0.432	
	@ Seas	0304 22 46 42					
	SAIL	0304 21:19:00.985539	-14.461			-15.143	
	@ Bigt	720479941					
57	CK51				0304 21:19:47.000682	-0.682	-14.623
	SAIL	0304 21:19:31.000162		+0.162		-0.520	
	@ Seas	0304 21 19 31					
	SAIL	0305 12:51:53.985930	-14.07			-14.787	
	@ Big	720535914					
58	CK46				0305 12:52:59.000717	-0.717	-14.392
	SAIL	0305 12:52:40.000322		+0.322		-0.395	
	@ Seas	0305 12 52 40					
	SAIL	0305 13:53:49.981823	-18.177			-18.897	
	@ Bigt	720539630					
59	CK18				0305 13:55:28.000720	-0.720	-18.518
	SAIL	0305 13:55:06.000341		+0.341		-0.379	
	@ Seas	0305 13 55 06					
	SAIL	0305 13:16:31.981616	-18.384			-19.102	
	@ Bigt	720537392					
60	CK29				0305 13:17:33.000718	-0.718	-18.528
	SAIL	0305 13:17:16.000144		+0.144		-0.574	
	@ Seas	0305 13 17 16					
	SAIL	0305 11:28:56.981287	-18.713			-19.426	
	@ Bigt	720530937					
61	CK17				0305 11:30:01.000714	-0..714	-18.530
	SAIL	0305 11:29:46.999818		-0.182		-0.896	
	@ Seas	0305 11 29 47					
	SAIL	0304 22:16:29.982162	-17.838			-18.523	
	@ Bigt	720483390					
62	CK30				0304 22:18:26.000685	-0.685	-18.559
	SAIL	0304 22:17:33.000721		+0.721		+0.036	
	@ Seas	0304 22 17 33					
	SAIL	0305 11:57:49.979384	-20.616			-22.707	
	@ Bigt	720532670					
63	CK41				0305 11:59:05.000716	-0.716	-19.90
	SAIL	0305 11:58:46.997909		-2.091		-2.807	
	@ Seas	0305 11 58 47					
	SAIL	0304 23:32:13.985996	-14.004			-14.692	
	@ Bigt	720487934					
64	CK27				0304 23:33:44.000688	-0.688	-14.631
	SAIL	0304 23:33:09.000627		+0.627		-0.061	
	@ Seas	0304 23 33 09					

Modifications to the Hydrophone Pre-amplifier

Modification 1 Data from the FARA 01 deployment showed that one second GRA spikes were being coupled into the hydrophone channel. The most probable path for the coupling is through common grounds. Figure A6.21.shows the signal ground path and the power ground path were the same for the FARA 01 deployment. Any coupling in the power ground from the geophones would also be coupled to the hydrophone preamp. That is, a change in voltage on the ground point of the power supply board would be added to the signal produced by the hydrophone

Figure A6.22 shows the changes made to the hydrophone preamp grounds to eliminate stray signals in the power ground from coupling to the hydrophone preamp. Stray currents in the power supply ground will bypass the hydrophone signal return.

Modification 2 Data from the FARA 01 deployment also indicated that there were a large number of triggers on the micro-seism peaks when the hydrophone channel was used. The hydrophone preamp is AC coupled to the Notch filter of the Acquisition package and this offered an easy way to put a pole at 10 Hz to reduce the gain of the hydrophone channel in the micro seism band. The gain of the input stage to the notch filter without the AC coupling from the hydrophone preamp is given by equation 1.

$$\frac{Vout}{Vin} = \left(\frac{1}{R_5}\right)\left(\frac{R_7 R_6}{R_7 + R_6}\right)\left(\frac{S + \left(\frac{1}{R_7 C_6}\right)}{S + \frac{1}{(R_7 + R_6)C_6}}\right)$$

With the coupling capacitor from the hydrophone preamp installed as shown in Figure A6.23 the gain of the input stage of the notch filter is given by equation 2 adding a zero at DC and a Pole at :

$$f = \frac{1}{2\Pi R_5 C_4}$$

$$\frac{Vout}{Vin} = \left(\frac{1}{R_5}\right)\left(\frac{R_7 R_6}{R_7 + R_6}\right)\frac{(S)\left(S + \frac{1}{R_7 C_6}\right)}{\left(S + \frac{1}{(R_7 + R_6)C_6}\right)\left(S + \frac{1}{R_5 C_4}\right)}$$

For the FARA 01 deployment C4 was an electrolytic capacitor with a value of 1uf which set the corner frequency at 1.25 Hz. For the FARA 02 deployment a 0.1 uf ceramic capacitor was used for C4 which put the corner frequency at 12.5 Hz (The choice of capacitor values was mitigated by the values that were available in quantity aboard ship).

Modification 3 Prior to the FARA 01 Cruise capacitor C2 on the hydrophone preamp board had been changed to a 22 uf electrolytic capacitor to adjust the corner frequency of the preamp. There was concern that the corner frequencies, from one preamp to another, may vary widely. Therefore C2 was changed to a precision 1% 20 uf capacitor. R3 was changed to a 10 Kohm 1%. (Again the choice of values was mitigated by the values that were available in quantity).

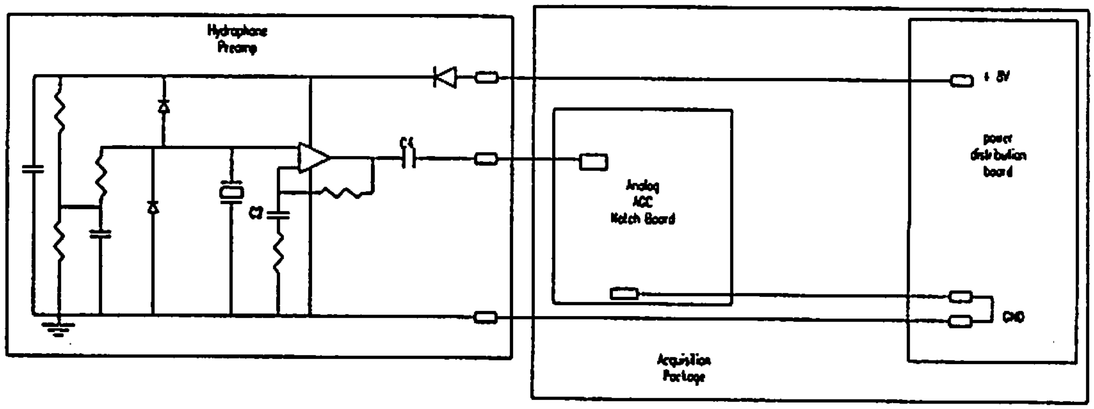


FIGURE A6.21 The schematic above shows the signal and power ground paths as they were for FARA 01

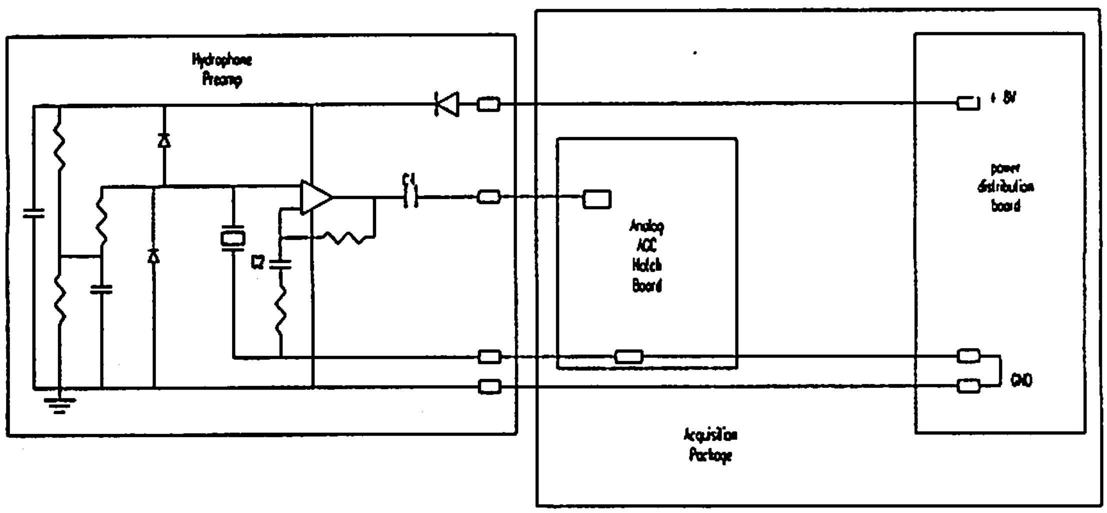


FIGURE A6.22 The schematic above shows the changes made to the preamp grounds to eliminate stray signals in the power ground from coupling to the hydrophone preamp.

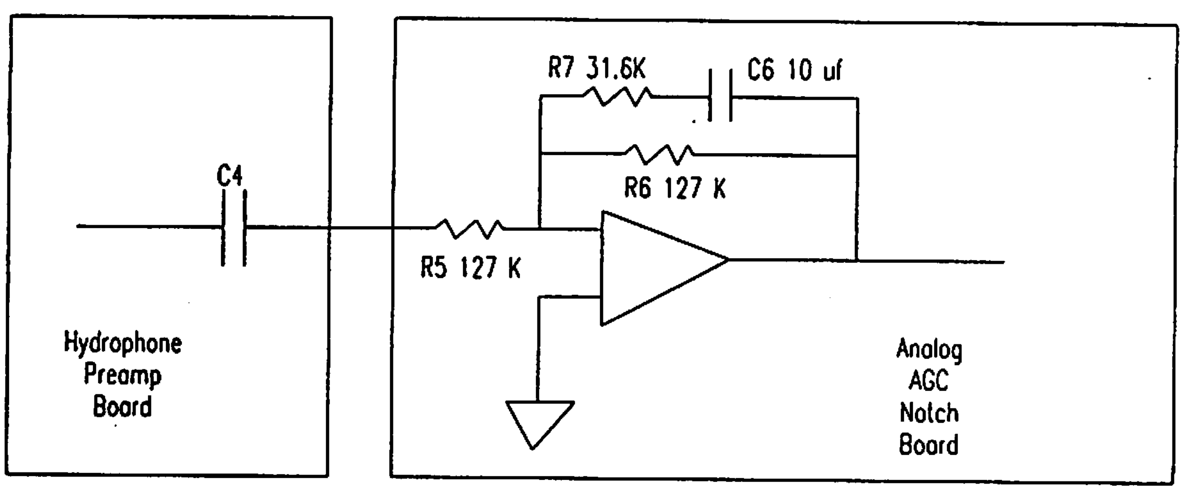


FIGURE A6.23 For FARA 02 capacitor C4 was replaced by a 0.1 uf ceramic capacitor to move the corner frequency to 12.5 Hz and attenuate microseism noise.

PRE-AMP RESPONSE TESTS 24th October 1992

In order to attenuate the 5 second microseism peak and so reduce the number of false triggers experienced when detecting events on the hydrophone channel, modifications were made to the hydrophone preamplifier to reduce its response to low frequency energy.In fact three changes were made:

the 22 microfarad electrolytic capacitor was replaced by a 20 microfarad high quality capacitor.

the signal ground and power ground were separated

the 11K resistor was replaced by a 10K

the coupling capacitor was changed from 1 microfarad to 0.1 microfarad

A function generator was then used to input a sine wave to the preamplifier that was connected to acquisition package # 53.For each test about 20 seconds of data were recorded into the acquisition package's memory and then plotted out on the 386's screen as raw A-to-D counts.

Identical tests were carried out with an 'old' unmodified preamp (as used in FARA 01) and with a preamp modified as described above.The results are tabulated below:

Frequency	0.2	1.0	4.0	8.0	12.0	20.0
Old	39378	22385	261600	549120	712448	675776
Modified	4000	3788	86756	341424	493664	604480
Change(dB)	**-19.8**	**-15.4**	**-9.6**	**-4.1**	**-3.2**	**-1.0**

Peak-to-peak input signal levels for these tests were set at 1 Hz to be 7.5 millivolts and the output of the function generator was not touched, except for the 0.2 Hz measurement that was carried out with a signal level of approximately 25 millivolts. Uncertainties in the above measurements are estimated to be +/-2-3 dB. A non-linearity was discovered in the anti-alliassing filter that produced a different response (by 10-20%) when lower signal levels were used in the test. The decision was made not to address this issue at this time.

The circuit diagram for the hydrophone preamplifier as deployed in FARA 02 is shown in Figure A6.24

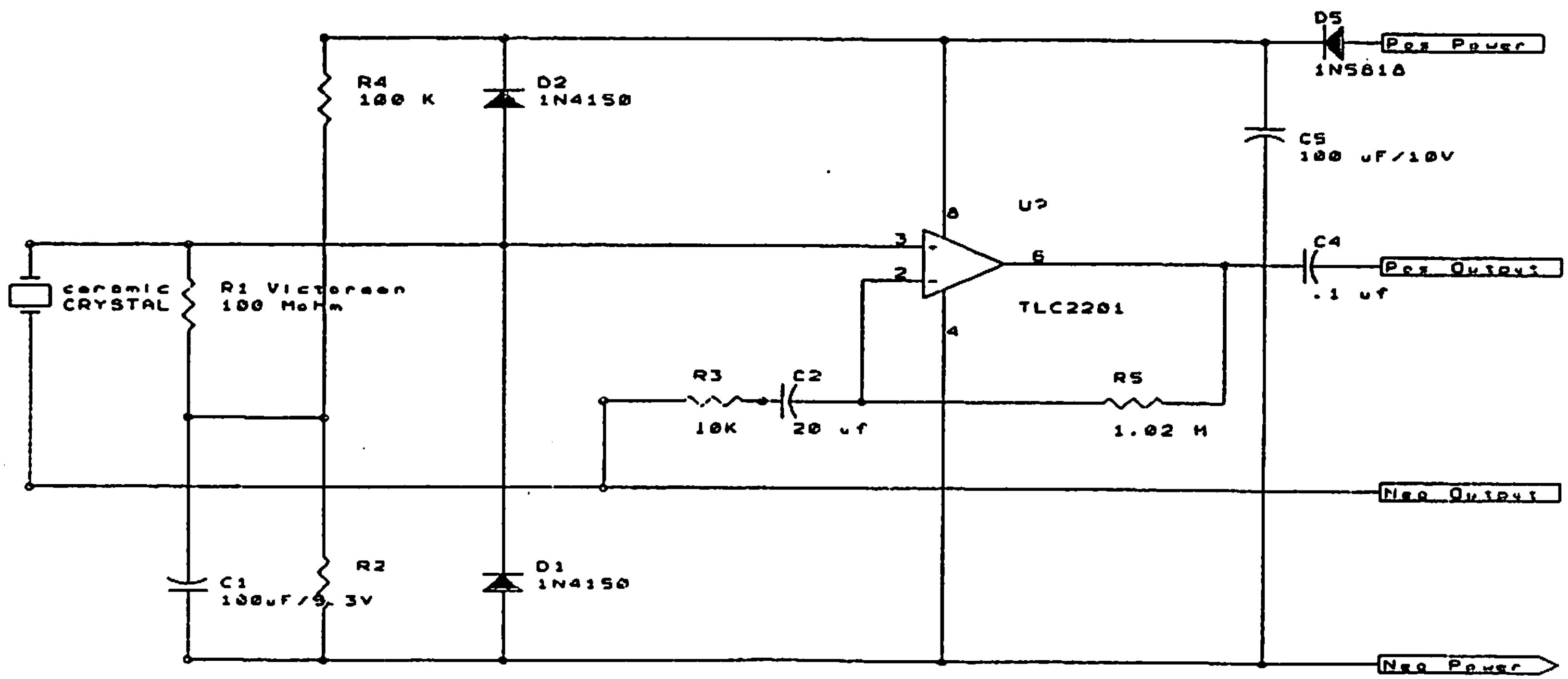


FIGURE A6.24 Circuit Diagram for the hydrophone preamplifier as deployed for FARA 02

Maxtor Recorder Issues

The first indications of disk writing problems were depleted voltages on the +28 Volt batteries. One possibility was that some unscheduled event had caused the battery pack to open up. To test for this possibility the voltage on each +28 Volt Battery was measured while it was still in the pressure case. Those batteries which did not have a full voltage of at least 29 volts were removed from the recorder package and examined on the bench. Each battery was examined for breaks in the insulation, burn marks, marks that would indicate a short circuit, breaks in the insulation of the wire, or any abnormality. After careful examination, the voltage of each cell of the battery stack was measured individually and the thermal (FT) and electrical (FI) fuses were removed from the stack and measured for continuity. (Additionally the blocking diode for each stack was measured for forward and reverse conduction (F/R Diode). Table 1 summarizes the results.

Table 1 +28 Volt Battery Evaluation

Obs #	Case Volt	Total Cell Volt	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9	Cell 10	F I	F T	F/R Diode
62	1.9	2.38	1.15	0.14	0.16	0.16	0.11	0.14	0.19	0.14	0.19	0.00	.1	.1	.14/O
58	23.2	23.2	2.95	2.86	1.77	2.95	2.95	2.95	2.95	2.78	0.43	0.59	.1	.1	.15/O
51	30.0														
59	16.0	16.1	2.92	0.33	2.93	2.92	2.79	0.32	0.32	0.34	0.29	2.91	.1	.1	.13/O
53	9.98	9.94	0.14	2.90	2.90	0.13	0.21	2.90	0.19	0.24	0.19	0.14	.1	.1	.14/O
63	11.8	11.2	0.30	2.91	0.31	0.28	0.53	2.93	0.27	0.70	0.34	2.92	.1	.1	.13/O
57	30.0														
56	29.9														
52	11.1	10.2	0.31	1.03	0.20	0.29	0.35	1.65	2.91	0.23	2.91	0.32	.1	.1	.16/O
64	30.0														
60	4.	3.91	0.10	0.11	0.11	0.09	2.91	0.17	0.18	0.13	0.11	0.00	.1	.1	.14/O
61	16.1	15.8	2.91	0.36	0.40	0.31	0.31	2.66	2.91	0.40	2.91	2.91	.1	.1	.16/O
50	1.4	1.48	0.02	0.00	0.00	0.50	0.17	0.16	0.02	0.14	0.30	0.17	.1	.1	.14/O
54	13.2	11.0	2.92	0.26	0.29	2.91	0.29	0.28	0.50	2.92	0.31	0.28	.1	.1	.15/O

For all the batteries examined none could be found that had breaks in the insulation, or indicators that a stray current path had been established which would explain the drain in power of the battery. Each of the batteries looked pristine. It is clear from the examination that the low voltages are the result of an across all cells power drain as opposed to, for example, a single cell that had opened up.

The batteries were drained therefore, by the normal functioning of the recording package. The recorder package uses an NCR 53C80 SCSI interface chip to control the Maxtor RXT-800S Write Once Read Many (WORM) optical recorder. It treats the NCR 53C80 as a series of registers that it can write commands and data into and read status and data from. The general procedure is to write something into the chip and then hang in a loop interrogating the chip to confirm that some event has happened or that some status has been achieved. Obviously if the code were allowed to remain in the loop indefinitely waiting for an event there would be some instances where the particular event or status would never happen and the recorder would be "stuck" forever in the loop. To prevent the recorder from becoming stuck a simple scheme is used to "time-out" the loop. When the loop is first entered a counter is set to zero and is incremented each time the status or event is checked for. When a predetermined number of counts have occurred, the scheme causes a bit in an error byte to be set and exits the loop with a "fail" for the return statement. The error bytes are located in a section of RAM that is not cleared upon reset and, therefore, the error indicators are available to be examined when the instrument is debriefed. Table 2 lists the error codes that were returned for the FARA 01 deployment along with the amount of data that the disk recorded and the battery voltage measured when the recorder was first opened after recovery.

TABLE 2

OBS No.	GOTO SLP 0	DIS WRT 0	DIS WRT 1	WORM INIT 0	COMPLT	STEXPE	STATUS INDICAT	MB	Disk init OK	28 V	28 Bat Ins
62	0x29	0x11	0x01	0x65	0X08		No Power	0.000	No.	1.9	OK
58	0x02	0X30	0X01				No Power	0.262	No.	23.2	OK
51							Zero's	215	Yes	30.0	OK
59	0x5E	0x15	0x01	0x05	0x0A		No Power	400	No.	16.0	OK
53	0xFF	0x11	0x01	0x01		0x01	Confused	16	No.	9.98	OK
63	0x01	0x10	0x01				Confused	400	No.	11.8	OK
57							Zeros	225	Yes	30.0	OK
56	0xED	0x11	0x01	0x01			Message	336	Yes	29.9	OK
52	0xFF	0x19	0x01	0x01		0x01	Confused	16	No	11.1	OK
64							Zero's	331	Yes	30.0	OK
60	0xA5	0x11	0x01	0x05	0x08		No Power	000	No	4.0	OK
61	0x05	0x15	0x01	0x05	0x08		No Power	400	No	16.1	OK
50	0x02	0x30	0x01		0x08		No Power	0.260	No	1.4	OK
54	0x13	0x15		0x05	0x08		No Power	400	No	13.2	OK

The meanings of the error codes are as follows:

GOTOSLP 0: This code is different than all the rest in that this is a counter and reflects the number of times the recorder tried to dump 4 Mbytes of data to disk and failed in the attempt.

DISWRIT 0, 0x01: This indicates that the worm initialization function was not completed successfully.

DISWRIT 0, 0x10: This indicates that the DMA chip did not return an End of Process

DISWRT 0, 0x20: Indicates the bus transaction could not be completed successfully when writing to disk

DISWRIT 1, 0x01: The routine to dump 65 Kbytes of data to disk failed.

WORMIN 0, 0x01: The SCSI Bus is not in the bus free state

WORMIN 0, 0x04: Could not do a complete transaction from status or message mode

WORMIN 0, 0x20: SCSI bus did not respond to a request sense command.

WORMIN 0, 0x40: Maxtor did not enter the Datain mode during a data transfer

COMPLT 0, 0x08: Request did not go away in message complete module

COMPLT 0, 0x02: Request did not go away in status mode

STEXPE 0, 0x01: Failed to write to disk 256 times.

The error codes summarized in Table 2 indicate a general failure rather than pointing to a single source. That is, some of the error codes are mutually exclusive and the only way to have two or more of the codes in the error messages is to have multiple attempts to pass through the code with a failure in different places during each pass. This is most likely caused by the attempt to get a full disk of data by continuing to collect data far beyond the 400 Mbytes that will fit on the disk. A full disk of 400 Mbyte requires approximately 100 successful dumps to disk. On two of the instruments the recorder attempted to dump to disk 256 times after writing 16 Mbytes to the disk. The kinds of error codes we see here are most likely generated as a result of the low voltages on the battery rather than an indicator as to why the voltages are low.

Selseq.c , which was part of the FARA 01 Recorder code, is an example of a time out routine that waits for the Maxtor to enter the Data Out mode. However this time out is flawed due to the semicolon at the end of the "while" statement. Because of the semicolon the routine to increment n and to check to see if it has reached the magic number of 0xffff is never entered and the code will hang for ever if necessary until the current status of the Maxtor includes the Data out mode. This routine is the key to many of the dead batteries and the failure to write data to some disks..

SELSEQ.C

```
n=0;
  while (((ibyte = inportb(cursta)) & trans_phase) != Dataout_mode);     /* A semicolon
here is a problem */
   {
     n++;
     if(n == 0xffff)
     {
       ebyte = peekb((eselseq + 0), mem64) | 0x08;
       pokeb((eselseq + 0), mem64, ebyte);
       /*eselseq[0] = eselseq[0] | 0x08;*/
       report();
       return crunch;
     }
   }
  return (0);
```

When the recorder is "awake" it spends its time in the loopdela() function. Here it compares the number of bytes stored in RAM against the dump limit of 3,670,016 bytes and it checks for a "go to sleep" flag . If the limit is reached the recorder calls the dump_ramble routine which writes all the data that is in the 4 Mbyte memory to the optical disk. There are many time out loops in the dump_ramble routine and in the routines that it calls. One of the time out routines is the "wait for the data out phase" routine described above. If one of the time out routines "times out" the routine will set the appropriate error code and return "crunch" (0xFF) to the loopdela() function. When "crunch" is returned to loopdela(), loopdela() grabs the existing count in the error code "gotoslep 0", adds one to it and returns the sum to the error code. Thus, the error code "gotoslep 0" is a count of the number of times the recorder has attempted to write to disk and failed. When the count reaches 256, the loopdela() function is exited and the recorder ceases to attempt to write to disk. If the count 256 is not reached the code will continue to try to write to disk until either the "go to sleep" flag is set or until 256 is reached.

GOTOSLP.C

```
loopdela()
{
  unsigned char ibyte;
  unsigned int i;
  unsigned char ebyte, ubyte[8];
  unsigned char err, cnt;

     if (go_to_sleep_flag == go_to_sleeep)
     {
       intsoff();
                 /* additional code here not shown for brevity */
       if(go_to_sleep() == crunch)
       {
         Maxoff();
         err = 0x08;
```

```
            cnt = 1;
            gotoerr(err, cnt);
            return crunch;
          }
      }
      else
      {
        if (blkflg == 2)        /* 8 blks X 4 segs/blk X 65536 bytes/seg */
        {                       /* = 2,097,152 bytes */
          if (blkptr2 == 0x60)    /* 6 blks X 4 segs/blk X 65536 bytes/seg */
          {                 /* = 1,572,864 bytes => 3,670,016 total */
            ibyte = dump_ramble();     /* = magic number to dump */
            if(ibyte == crunch)
            {
              ebyte = peekb((gotoslp + 0), mem64) + 0x01;
              pokeb((gotoslp + 0), mem64, ebyte);
              dump_flag = reset;
              SCSIstatus();
              DMAstatus();
              Maxoff();
              if(ebyte == 0xFF)
                return crunch;
            }
          }
        }
      }
}
```

In general, the acquisition package activates the wake up line and begins to send data to the recorder. At some point during the transfer of data the number of bytes stored in memory reaches 3,670,016 and the recorder begins to dump the contents of the four megabyte memory to disk. The acquisition package may, during the write to disk period, finish emptying its buffer and toggle the wake up line low causing a "go to sleep" flag to be set in the recorder by the toslep() function. When the recorder exits the dump_rambles routine, either by successfully writing to disk or by a time out routine, It checks the "go_to_sleep_flag" and, if the flag is set, turns the interrupts off and calls the go to sleep function. The go to sleep function, among other things, calls the snooze function which puts the recorder in the sleep mode but more importantly positions the code to reactivate the serial link when a wake up signal is received. In other words if the recorder code does not get to this position after its serial link UART has been disabled, the recorder will not take in any more data over the serial link. And the recorder serial link UART will always be disabled when the acquisition finishes dumping its buffer.

```
go_to_sleep()
{
        /* additional code here not shown for brevity */

   snooze();
   intson();              /* turn interrupts on. */
```

```
  return _zero;
}
```

```
snooze()
{
  unsigned int i;

  /*Sent to bed*/
  outportb (slimcr, (SIO_disable_ints | DTR_low)); /* disable UART */
  peekb(0xA000, 0xF000);          /* This puts the recorder to sleep */
            /* The wake up line causes wake up at this point */
      set_receive();    /* Set up UART to take in data */
  outportb (interupt_control, togle_low);  /* clear interrupt request line */
  outportb (interupt_control, togle_high);
  go_to_sleep_flag = wakeup;          /* clear go_to_sleep_flag */
  inportb(slnrbr);        /* read UART to clear any extraneous bytes */
                  /* due to turn on */
  /*Awakened*/              /* return to snooze */
}
```

The toslep function is called in response to an interrupt generated by the wake up line going low. This function will be called regardless of where the back ground code is running and therefore the Recorder serial link UART will always be disabled when the acquisition package finishes transferring data and toggles the wake up line low. Disabling the serial link UART is necessary because the acquisition package will change the BAUD rate of its UART in anticipation of two way communication on the serial link when it is finished emptying its buffer. This may cause glitches on the serial data line which the recorder, if its UART is not disabled, would treat as a data transfer and add the extraneous glitches to the data stream as if it were data.

```
/*:ts=8*/
/*****************************************************************
                    toslep.c
*****************************************************************/

#include "include\rec.h"
#include "include\rec.e"
#include "include\cpu8088.h"


toslep()
{
outportb (slimcr, (SIO_disable_ints | DTR_low));    /* disables the serial link UART */
go_to_sleep_flag = go_to_sleeep;
```

```
outportb(interupt_control, togle_low);
outportb(interupt_control, togle_high);
}
```

Some Scenarios:

Assume there is some cause that prevents the recorder from successfully writing the contents of memory to disk. (Such as a tilt angle greater than 15 degrees). The first scenario is that the dump_rambles routine is called and the Maxtor stumbles to get several tens of kilobytes onto the disk but can not do more than that. One of the time out routines will set an error flag and return crunch. The counters that keep track of where on the disk the data will be put may or may not have been adjusted depending on where the time out has occurred. If the go to sleep flag has not been set when dump_ramble() function has been exited, the recorder will again attempt to write to disk. If the counters have not been incremented the recorder may try to over write areas already written to. If the counters have been incremented the recorder may be skipping blocks not written to. In any event the Maxtor will have a message to give and will not enter the data out phase until the message is read. Therefore the code will hang in the :"Dataout_mode" while loop. During this hang the Acquisition package will finish transferring its buffer and will toggle the wake_up line low and the toslep() function will be called and the recorder UART will no longer take in data. Since the power to the Maxtor is on, during this hang, the +28 volt battery will be drained. The battery does not lose its voltage instantaneously, however, and the weak and dying voltage may cause the 5 volt logic levels to fluctuate. It is even conceivable that the fluctuating logic levels will reach a state that satisfies the condition of the "Dataout_mode" while loop and the loop will be exited without setting an error flag and the go to sleep routine will be called and on the next recorder wake-up the recorder will continue to take in data. This was confirmed by bench tests where the lab voltage supply had its current limit reduced after the recorder had hung up with the +24 volt supply on. The code recovered, turned the Maxtor supply off, and continued to take data. It is also possible that the conditions of the "Dataout_mode" while loop will not be met and the recorder code will hang here until debriefed. This was also confirmed by lab tests.

OBS #53 and #52 Scenario: These instruments have marginal cause for failing to dump to disk. Some data gets on the disk but problems arise and failed attempts to write to disk are recorded. The counters are not always set properly and the data on disk may be fractured or blocks may not be written to. As the instrument soaks in the cold environment the ripple on the power regulator increases and the margins for failure become more severe. Two paths may have occurred. One - the "Dataout_mode" while loop was encountered and the system hung up until the battery was drained to the point at which oscillations in the SCSI bus caused the conditions of the while statement to be met, the code called the go to sleep routine which reset the conditions to continue to receive data. Each time the magic number of bytes was reached the dump_rambles routine failed due to, for instance, a call to a function to check if the End Of Process Flag from the DMA chip got set (a function call with a very long time out routine) because the +28 volts was depleted and each time the dump_ramble routine was exited the go to sleep flag was set sending the recorder to sleep. Eventually (on day 267) the count of 256 was reached and the loopdela() function was exited and on the next toggle of the wake-up line the serial link UART was disabled and no more data was taken into recorder memory. The second scenario is similar to the first except that it assumes that the "Dataout_mode" while loop was not encountered but that because of the inability to write to disk due to the root cause, 256 failed attempts to dump to disk (two and one half times the normal number of attempts to dump) with long time out routines were sufficient to drain the battery.

OBS #58 scenario: This disk was full. The scenario for 58 is that it had 5071 events at 41 seconds apiece or 207911 seconds of event data. 207911 X 1056 bytes per second = 219,554,016 bytes of event data was collected. Also, 165,300 seconds of continuous data @ 1056 bytes per second = 174,556, 800 bytes of continuous data and 60 X3 = 180 seconds @ 1046 bytes per second = 190,080 bytes of cal data were collected for a grand total of 394,300,896 bytes of data which is enough to call a full disk but which did not cause any overwrite attempts and, therefore, caused no error codes.

OBS #54, #59, #61, #63 scenario: These disks were full. The scenario for each is that on day 278 the disk was filled. The next attempt to write to disk stimulated the Maxtor to enter the message mode to complain that it was commanded to fill a logical block that could not be accessed. The code hung in the "Dataout_mode" while statement because the Maxtor had a message to give and would not enter the data out mode until the message had been read. This hang up caused the battery to drain and the serial link to shut down.

OBS Numbers 51, 57, and 64 did not experience problems writing to disk.

OBS #56 did experience problems writing to disk. The status flags indicate that the Maxtor had a message to send. At some time during the deployment the recorder was unable to complete the worm initialization routine. This could explain the absence of continuous data. Since the battery was not drained the recorder did not get hung in the "Data Out" mode and upon each power on would have started with a clean slate. Therefore, the assumption is that after experiencing a problem the first time the LBA counters were not reset properly and the disk continuously tries to write to LBAs that were already written.

OBS #62 no assessment

OBS #50, #60. The scenario here is that the tilt of the frame caused the Maxtors to fail to write data. The code hung up in the "Data Out " mode with the Maxtor powered on. The Battery was drained and the serial link was shut down by the toslep function causing cessation of data over the link.

THE CHANGES

Changes were made to the recorder code modules "gotoslp.c selseq.c, and diswrt.c " creating version 1.0 of the code. The function call to resetit() was inserted into the error loop of the "gotoslp.c" module to clear the blkflg = 2 and blkptr2 = 0x60 registers so that the code would not continuously try to dump the same 4 Mbytes of data to disk after experiencing a failure. The code will, in version 1.0, wait for the gotosleep flag and call the gotosleep function after a failed attempt to write to disk.. this will reduce the number of attempts to write to disk and allow a substantial amount of time to elapse between writes when there is a problem. This change was put to good use during the Test deployment of OBS #54. The first time the recorder attempted to write to disk during the test deployment, the sugar releases had not released the geophones. Therefore the added weight at the geophone end of the frame caused it to be tilted by as much as thirty degrees. The attempt to dump data failed and the recorder retired to the sleep mode to awaken in an hour after the releases had deployed the geophone and the frame had come to level. Subsequent dumps were completed successfully.

GOTOSLP.C

```
else
{
  if (blkflg == 2)   /* 8 blks X 4 segs/blk X 65536 bytes/seg */
  {                     /* = 2,097,152 bytes */
    if (blkptr2 == 0x60)  /* 6 blks X 4 segx X 65536 bytes/seg */
    {                /* = 1,572,864 bytes => 3,670,016 total */
      if (LBAcounter < 0x2ebd0)  /* full disk number */
      {
        ibyte = dump_ramble();
        if(ibyte == crunch)
        {
          ebyte = peekb((gotoslp + 0), mem64) + 0x01;
          pokeb((gotoslp + 0), mem64, ebyte);
          dump_flag = reset;
          SCSIstatus();
          DMAstatus();
          Maxoff();

          resetit();                     /* This prevents continuous dumps of the same
4 Mbytes */

          if(ebyte == 0xFF)
            return crunch;
        }
      }
    }
  }
```

Diswrt.c was changed in all routines that incremented the LBAcounter. The old code incremented the counter at the end of the function and may not have incremented it if the function had an unfavorable exit as in example diswrt.c 1.

diswrt.c 1

```
for(i=0; i<blocks_per_rambo; i++)
{
  writ[3] = (LBAcounter & max_high_bytes);
  writ[2] = ((LBAcounter>>8) & max_high_bytes);
  writ[1] = ((LBAcounter>>16) & max_high_bytes);

  outportb (rambo1, blkptr);
  blkptr = blkptr + blkinc4;
  if(sendwrt(0xFF, 0xFF) == crunch)
```

```
        {
          err = 0x01;
          cnt = 1;
          diswrte(err,cnt);
          return crunch;
        }
        LBAcounter = LBAcounter + max_blocks;      /* This counter would not be
incremented */
    }                                            /* if a failure occurred */
```

Version 1.0 increments the LBAcounter prior to the function call. Therefore the counter is always incremented regardless of the outcome of the function call as illustrated in diswrt.c 2. The efficacy of this was established during the test deployment. The counter was incremented by 64 Kbytes preventing the Maxtor from attempting to write to locations that may have the already written flag set.

diswrt.c 2

```
    for(i=0; i<blocks_per_rambo; i++)
    {
        writ[3] = (LBAcounter & max_high_bytes);
        writ[2] = ((LBAcounter>>8) & max_high_bytes);
        writ[1] = ((LBAcounter>>16) & max_high_bytes);

        outportb (rambo1, blkptr);
        blkptr = blkptr + blkinc4;
        LBAcounter = LBAcounter + max_blocks;   /* This counter is incremented
regardless of the */
        if(sendwrt(0xFF, 0xFF) == crunch)          /* exit routine */
        {
          err = 0x01;
          cnt = 1;
          diswrte(err,cnt);
          return crunch;
        }
    }
```

The semicolon is removed from the while statement in the selseq() function thus eliminating the hang forever problem.

SELSEQ.C

```
 n=0;
  while (((ibyte = inportb(cursta)) & trans_phase) != Dataout_mode) /* The semicolon is
removed */
  {                                                          /* from here. */
    n++;
    if(n == 0xffff)
    {
      ebyte = peekb((eselseq + 0), mem64) | 0x08;
      pokeb((eselseq + 0), mem64, ebyte);
```

```
        /*eselseq[0] = eselseq[0] | 0x08;*/
        report();
        return crunch;
    }
}
return (0);
```

CONCLUSIONS

The root cause of the Maxtor failures can only be guessed at. The most likely candidate is that severe tilt angle of the frames prevented normal writing to disk, the recorder code did not recover gracefully from the root failure causing additional paths of failure.

GRA spikes and Grounding

The data from FARA 01 confirmed that geophones which are thought to be oriented such that they are against their stops produce very large one second GRA spikes in the data. To investigate this problem a three axis sensor was placed on its side in the lab and data was collected. Despite changing the orientation of the geophones several times the magnitude and frequency of the spikes in the FARA 01 data could not be duplicated. One difference between the lab environment and the water column is the water ground path between cases of the OBS that exists in the water column but not in the lab. Therefore a jumper was installed between the sensor case and the recorder frame to simulate the water path. The data collected contained GRA spikes comparable with the spikes in the FARA 01 data. The sensor was righted and data was collected. The data did not have the GRA spikes.

Therefore the assumption was that something was getting shorted to the case of the sensor when the geophones were at their stops. The sensor was opened, the gimbals were displaced to put the geophones at their stops, and the continuity between the case and each pin of the geophone connector was checked. When the geophones are at there stops they short to the case. This disrupts the signal return path and may directly interfere with the signal. Tim Barash confirmed that when the geophones are at there stops they do short to the case although he was not sure which end actually shorted. We need to do some further work here to identify which end shorts or if either end can short to the case.

THE FIX

Since the inside of the geophones are inaccessible, the one way to eliminate the geophone water wave path is to isolate the geophone housing from the sensor case. The implementation of this isolation is described in Appendix 11. All sensors were retrofitted with the isolation modification for the FARA 02 deployment.

The OBS Control Loop

The ONR OBS Control loop was used for a deployment for the first time during the instrument preparation of the FARA 02 deployment. The control loop functioned smoothly and eased the preparation process.

The FARA 02 pre deployment schedule modeled the kind of schedule described in the formative days of the OBS. That is, all of the OBS instruments were assembled on their frames, on the fan tail, complete and ready to deploy for several days before the actual deployment. They were available for testing, for reading and setting the clocks, for a leisurely programming. This was the scenario for which the ONR OBS Control Loop was created.

Each of the Seascan clocks was read several times and each clock was adjusted over the loop with out having to journey out to the fantail to disconnect from one system and connect to the other. Digital and analog checks were done on each instrument, again, without the effort and time of moving cables. However the Control Loop operation is not optimized yet and can be made to operate much more efficiently. The program to sequence through the instruments and read each Seascan clock periodically with the results saved in a file must be completed. Effort should be expended to make this a TSR program with an alarm clock so that reading the clocks will take place continuously without manual intervention.

The general procedure for programming the instruments for deployment treats each instrument as an entity, the programming of one instrument must be completed before the programming of the next can begin. This procedure does not take full advantage of the manifold capabilities of the Control Loop. With the loop it is possible to be running deployment checks on several instruments simultaneously dramatically shortening the time it takes to program all the instruments. However changes must be made to the microcode and to the OBS operating code to make a manifold programming sequence robust enough to be the standard of operations.

The table below shows the configuration of the loop used for the FARA 02 deployment. OBS# is, of course, the Frame number of the instrument. To distribute a relatively low voltage SAIL loop supply over up to 64 SAIL addresses the loop is divided into four current loops. The 'loop' column of the table indicates which of the four loops serviced the instrument. Each SAIL address occupies a 'cell' in the loop, each cell number being the number of steps away from the control box of the cell, and, therefore, of the SAIL address (cell #1 is the first cell on the loop, cell number 16 is the last cell on the loop). The SAIL column lists the acquisition and recorder SAIL addresses at each cell. The Seascan column lists the SAIL address of the clock at each address. Station is the serial number of the physical entity that connects the loop to the recorder.

OBS#	LOOP	CELL	S.A.I.L.	SEASCAN	STATION
61	0	01	2E	17	1
	0	02	51		
50	0	03	32	28	2
	0	04	15		
64	0	05	24	27	3
	0	06	21		
52	0	07	38	34	4
	0	08	59		
56	0	09	36	32	5
	0	10	11		
57	0	11	3C	51	6
	0	12	31		
54	0	13	40	37	7
	0	14	33		
59	1	01	26	18	8
	1	02	23		
51	1	03	34	39	9
	1	04	25		
60	1	05	2C	29	10
	1	06	55		
58	1	07	28	46	11
	1	08	27		
63	1	09	42	41	12
	1	10	19		
62	1	11	30	30	13
	1	12	13		
53	1	13	3A	31	14
	1	14	17		

The 100MB Lab Test

The intention was to record 100 Mb of 'data' (10Hz sine wave from a function generator) on every instrument and so establish its functionality. This would take about 26.5 hours. The test began at 2030LT on October 21st with 12 OBS. Two failed units had been discovered during the set-up procedures.. In attempting to find the cause of failure on these two instruments two other OBS were inadvertently powered down so it was decided to carry out a second separate test on the following day of these four units. The test set-up that allowed us to run all 14 OBS simultaneously had two flaws. The function generator signal was connected to the acquisition packages in an extremely tenuous manner - connectors were not used. Individual leads were attached to the separate pins of each acquisition package. Secondly, we were restricted in the kind of program we could run for the test because the power supplies could only reliably operate 2-4 Maxtor recorders simultaneously. So an attempt was made to uniformly distribute the predicted turn-on times of the Maxtors. This was only really possible in continuous record mode.

The analysis of these test results was made difficult because the primary failures observed in the data were almost all relatable to the test set-up.There were three primary characteristics:

On some of the units the sine wave ceased to be recorded on all four channels: correlation of the time at which this occurred showed that it was at exactly the same instant on all the instruments. Therefore we concluded it was due to a disconnection of the function generator leads. On several units optical disc recorder errors occurred that were accompanied by sets of empty data blocks that varied in duration from a few up to over one hundred minutes Correlation of the times at which these events occurred showed that they were at times at which multiple recorders were simultaneously powered up.Because it was known that the power supplies were incapable of maintaining more than a couple of Maxtors operating at the same time, again the conclusion was that this was not an indication of instrument failure. The volume of data lost due to this problem varied from instrument to instrument (see below) but always corresponded to the number of blocks lost when the Maxtor failed to write. The one exception to this rule (OBS # 54) was investigated in detail. Upon careful inspection of the disc on the NEC 386 computer no missing bytes could be located. Specifically the two sections of data that the SUN system had told us were missing were quite definitely in place and easily readable. We concluded therefore that this problem was unrelated to OBS performance and was a manifestation of an inadequacy in the data read-back capability.

Thirdly, there existed throughout the data pseudo-random glitches of almost identical character on all the units. Correlation of time across OBS's again convinced us that these noise spikes were somehow generated outside the OBS system.

As a result of these tests, one of the front-end boards on channel #3 of Acquisition package 51 was replaced, as was the serial link board in Acquisition 27 and the PAR-40 board in 31 was re-seated in its connector. The analysis of the results of this test required a massive effort. However if the conditions of the test could be improved to reduce the number of paths for spurious failures, then this is clearly a very powerful approach to the discovery of hardware and software failures.

100 MB LAB TEST RESULTS

OBS# OF BLK	BYTES RECORD.	EXPECTED BYTES	SLEEP ZEROS	MINS EMPTY
63	100188160	100743168	1	10
64	97189888	100743168	1	58
50	99790848	99792896	0	
51	93538304	100743168	3	112
53	100743168	100743168	0	
54	99792896	99792896	0	24 secs
56	99792896	99792896	0	
57	99176448	99792896	0	
58	100495360	100743168	0	
59	98136064	100743168	5	69
60	100743168	100743168	0	
61	100743168	100743168	0	
62	90875904	100743168	3	161
52	100743168	100743168	0	

Appendix 7 OBS Performance during FARA 01 Part 2

Summary

In the previous appendix the characteristics of the OBS performance were described in detail. Here an attempt will be made to provide a broad overview of the OBS system performance in general and determine and describe the root causes for the data losses that were incurred. A summary of this summary is provided in Table A7.1.

Two primary reasons can be identified as explanations for greater than 95% of the lost data: rough topography and old bad hydrophone sensors.

The original mechanical design for the OBS is not suitable for operations in the rough terrain of the Mid-Atlantic Ridge. The sensor package gimbals are designed to correct for only 15 degrees of tilt but, as is shown in Table A6.1, in only 4 cases did the sensor package come to rest within this limit. This causes loss of seismometer data directly but also is the primary cause of the infamous one second GRA spikes that also greatly mar the hydrophone channel. It is our (highly) subjective judgement that the problems with excessive sensor tilt were not simply a result of the sensor landing on small scale rough topography but were frequently exacerbated by the continued motion of the frame (upon landing on a slope) actually dragging the sensor over on its side. The use of the soluble release to delay the deployment of the sensor package until some time after the frame has landed on the seafloor should overcome this problem in FARA 02.

The Maxtor optical disc drive can withstand only 15 degrees of tilt along the long axis of the OBS frame. All the failures (in many different modes) of the Maxtor drive can be explained by the assumption that many of the frames came to rest on the seafloor at angles greater than this.A complete redesign of the anchor system, that allows the frame to float above the seafloor and self-level, will overcome this problem on FARA 02.

Many of the OAS hydrophone sensors used on the OBS instruments were purchased in 1977-78. At least six were determined to be defective following the FARA 01 deployment, and in one case a deep cut was found in one of the hydrophone leads. New sensors should be purchased and the leads themselves should be replaced regularly - ideally before every deployment.

The simple long-term/short-term average event detection scheme was inadequate to discriminate against microseism noise given the enhanced low frequency response of this recording system (relative to our previous instruments). Reduction of the low frequency response is the simple solution that was adopted for FARA 02 but more intelligent event detection schemes should be evaluated. The lock-out feature of our event detection software was extremely important. Recorded activity levels were extremely high. Given the instrument spacing in our network, the detection threshold (3) was obviously set too low especially on the vertical seismometer. In future a more discriminatory lock-out capability should be implemented whereby beyond some certain maximum number of events no more are recorded within a given period *unless* their long-term/short-term average exceeds some second larger threshold value. In this way the lock-out would not prevent the recording of large microearthquakes following a swarm of tiny events.

There remain a number of problems with the data acquisition system that were not solved for FARA 02 because they were not fatal problems and because they were extremely difficult to trace and understand.One notable example is the occasional occurrence of incorrect gain data in the headers that results in an obviously erroneous signal level for some fraction of a second. This characteristic was repeatedly reproduced on the lab test bench but no adequate understanding was gained of the root cause.

TABLE A7.1 SUMMARY OF OBS PROBLEMS

SYMPTOM	CAUSE	SOLUTION
No seismometer data False or non-trigger GRA spikes	Tilt of Sensor	Delay sensor deployment, insulate geophones from gimbals, *build new tripod baseplate.*
Recorder unable to write to disc Recorder hang-up and depletes 28v supply Recorder turn-off UARTs so recorder memory is not updated Missed/empty bytes are written on disc	Tilt of frame	Float frame above seafloor Modify recorder software
Bad hydrophone data	Old bad sensors	Replace sensors, *buy new*
False triggers	Bad hydrophone sensors Microseisms Spurious signals on seismometers (coupling/wobble?)	Remove low freq. *Refine detection algorithm* *Improve seismometer coupling*
Missed shots	Lock-out too low False triggers High activity level	Improve acquisition software and *refine the detection algorithm*
Incorrect gain data	Unknown hardware / software problem in acquisition package	*Identify and correct*

Appendix 8 FARA 02 Test

Because for the serious problems experienced with tilt during the FARA 01 deployment it was decided to make some substantial modifications to the anchor and sensor package deployment systems on the OBS. The details of these changes are described in Appendix 10. However they were considered sufficiently profound that a test deployment was planned to verify that the changes achieved their objectives and that no unforeseen problems were introduced. The key questions we wanted answered (besides the obvious and primary issue of the continued security in release and recovery of the system) were: By floating the package 17" above the seafloor, will it remain sufficiently level that all the problems with the Maxtor disc drive are removed? By delaying the deployment of the sensor until some time after the arrival of the instrument on the sea floor, can we increase the probability of level sensors? (i.e. were many of our previous problems due to catastrophic landings that resulted in the package being pulled over on its side?). Obviously, a single deployment of one instrument provides inadequate answers to these questions, but nevertheless it was considered a worthwhile activity given the small cost in time to the program.

For the test to be meaningful it was important to choose a site that was as close as possible to the terrain that we expected to encounter during the FARA 02 experiment. But to minimise time requirements consideration had to be given to the locations of the end points of the Hydrosweep survey lines.The chosen site was near the southern end of the ridge segment immediately to the north of that which was the subject of FARA 01. The deployment location for OBS #54 was 29° 18.3'N 42° 53.6'W. Water depth was 3331m. The OBS was launched in calm seas on a sunny 13th October at 1520Z. Impact with the seafloor was observed at 1608Z, confirming our previous sink rate estimate of 68m/min. As no anomalies were observed, the transponder was disabled, and the vessel departed the area. The program for data acquisition for this experiment (using PROM version 3.54 in the acquisition package) is given below:

TABLE A8.1 ACQUISITION PROGRAM FOR FARA 02 TEST

TASK 1	**1600Z/13th - 0400Z/14th**	*CONTINUOUS RECORD*
TASK 2	**0405Z/14th - 0800Z/14th**	*EVENT DETECT* VERTICAL TRIGGER RATIO - 3 LOCKOUT: 60 IN 4 HR
TASK 3	**0805Z/14th - 1200Z/14th**	*EVENT DETECT* HYDRO TRIGGER RATIO - 3 LOCKOUT: 60 IN 4 HOUR
TASK 4	**1205Z/14th - 1215Z/14th**	*CALIBRATION* AS PREV

The research vessel came on station to begin the recovery procedure at.at 1330 LT on 14th October. It was a calm, sunny day. Interrogation and release of the instrument was uneventful. And the unit surfaced at 1452LT, 5 minutes before its predicted time. The vessel was half a mile away from its intended position and visual siting was not immediately established. It surfaced astern of the vessel according to the radio bearings and upon reversing course visual contact was established. However the floating object to which the vessel then steamed was not the previously sited OBS but was a discarded polystyrene float. At this point we were approximately 1 n.m. from the OBS deployment position and could not locate the OBS visually. Upon steaming back towards the drop position and following the radio bearing from the VHF ADF the unit was finally spotted on the starboard beam as we steamed past it. The instrument was recovered on board at 1530 LT. All four RSLI (Rust Spot Level Indicators), the two on the frame and the two on the sensor package, indicated that the respective units had been level to within a few degrees. This was a great success!

Initial inspection of the data showed that the first 4 MB had not been recorded on the disc - an attempt had been made and an error message recorded following failure. This was consistent with the fact that until the sugar release allows the sensor package arm to fall, the instrument is definitely floating at a substantial angle to the horizontal. Once the arm is released then the frame is level and the Maxtor can function without difficulty - as indeed it did.The remainder of the data was excellent. A major spike event was interpreted to be the moment of release of the arm (see Figure A8.1).The time of this event is approximately 1710Z so, given that the instrument was launched at 1520Z, the soluble release that retained the arm is presumed to have let go after 1 hour 50 minutes in the water. This was not inconsistent with predictions.Attempts to identify a signal that might be associated with the moment of release of the arm from the sensor package were unsuccessful. Several small earthquakes were recorded during the 12 hour long continuous recording window (Figure A8.2).It is clear from this last figure that the vertical and horizontal seismometers are significantly more sensitive than the hydrophone. Event detect mode also worked well, (one example of a larger event is in Figure A8.3) but the hydrophone repeatedly was triggered by long period microseisms (Figure A8.4).Even with the 40 dB preamp we believe the hydrophone lacks gain in the 5-30 Hz band in this very quiet part of the ocean. Figure A8.5 shows noise riding on the long period microseism energy and inspection of the raw A-to-D counts shows that this higher frequency noise has an amplitude of only 100-200 counts.(out of the A-to-D).This might be the noise floor of the instrument and not ocean ambient noise.The OAS hydrophones have a specified sensitivity of -87 dB re 1 volt per microbar, which is approximately equivalent to 50 microvolts per microbar. With a GRA gain of X64 and a preamp gain of 40 dB, 200 counts out of the 5 volt 16 bit A-to-D converter corresponds to about 4.6 microvolts out of the hydrophone or approximately 0.1 microbars.

Our conclusion from these results is that the modifications achieved their objectives and that we should institute these changes on all the units we plan to redeploy at the end of this leg.

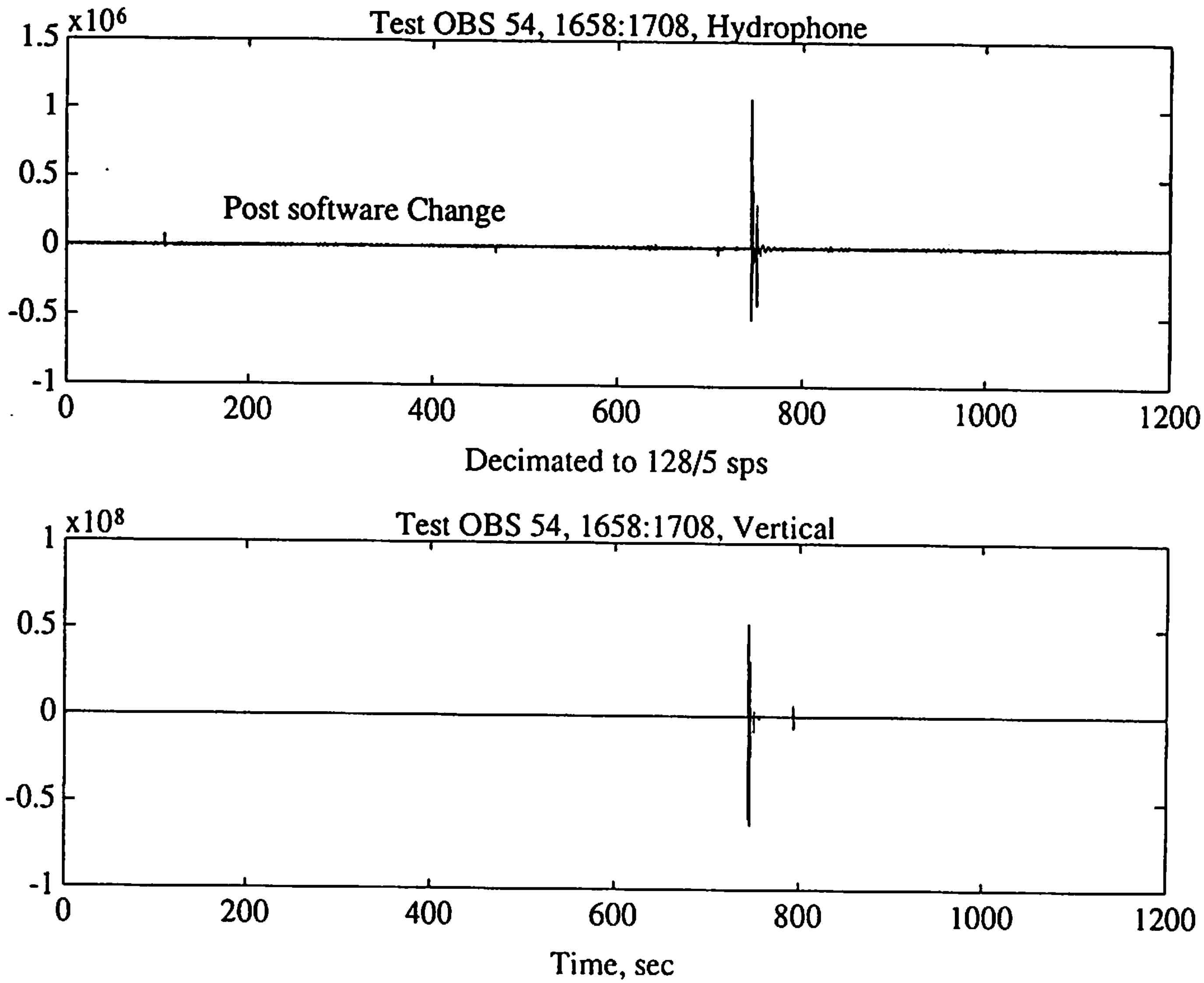


FIGURE A8.1 Records of the large amplitude spike on the vertical seismometer and hydrophone channels from the continuous recording phase that is interpreted to be the signature of the deployment of the seismometer arm.

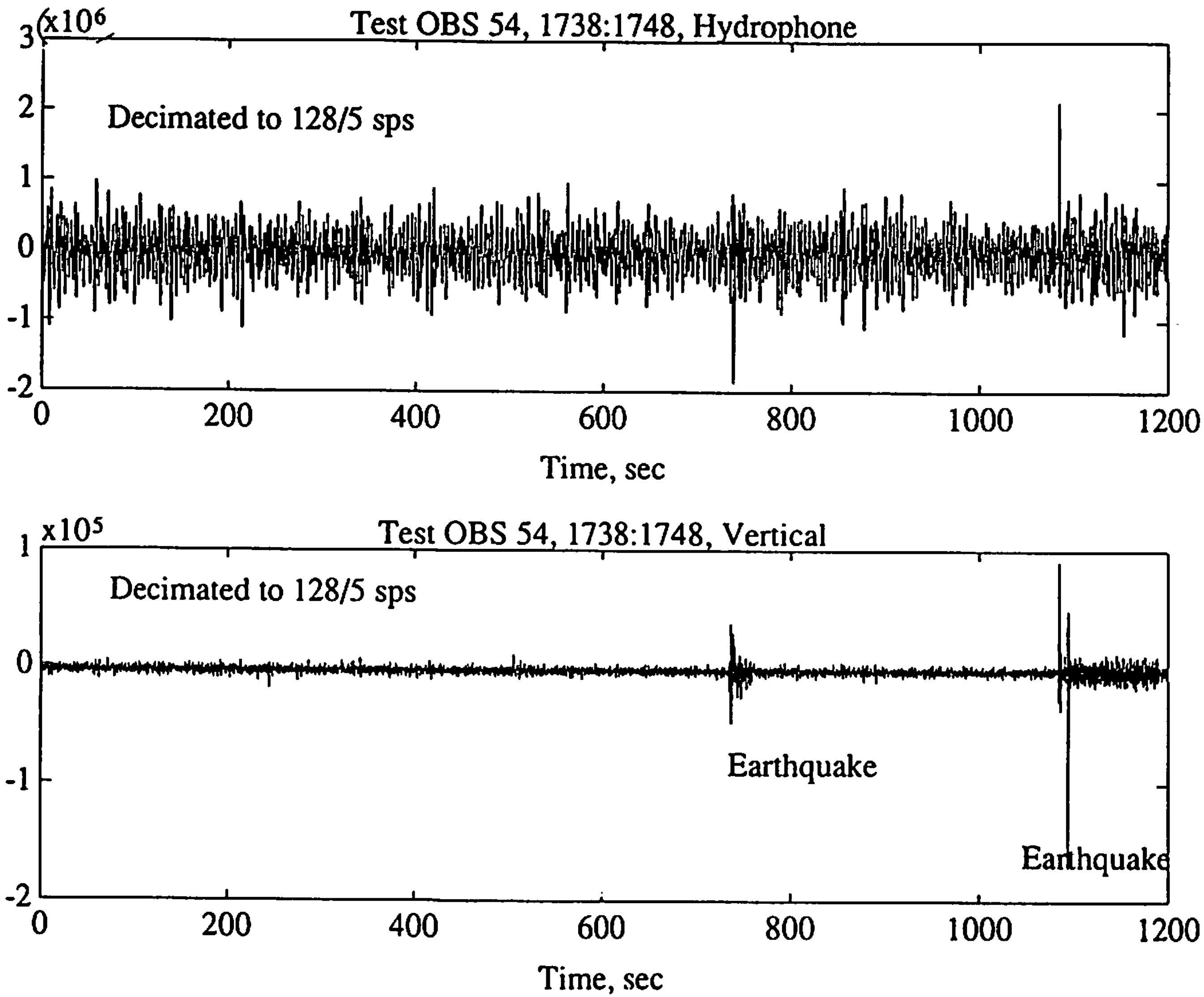


FIGURE A8.2a Twenty minute long segments of data from the continuous recording phase that show two small microearthquakes the shear waves from which are clearly identifiable on the vertical (and horizontal seismometers - see Figure A8.2b) but are hardly visible on the hydrophone. These traces have been decimated by a factor of five to speed the plotting process.

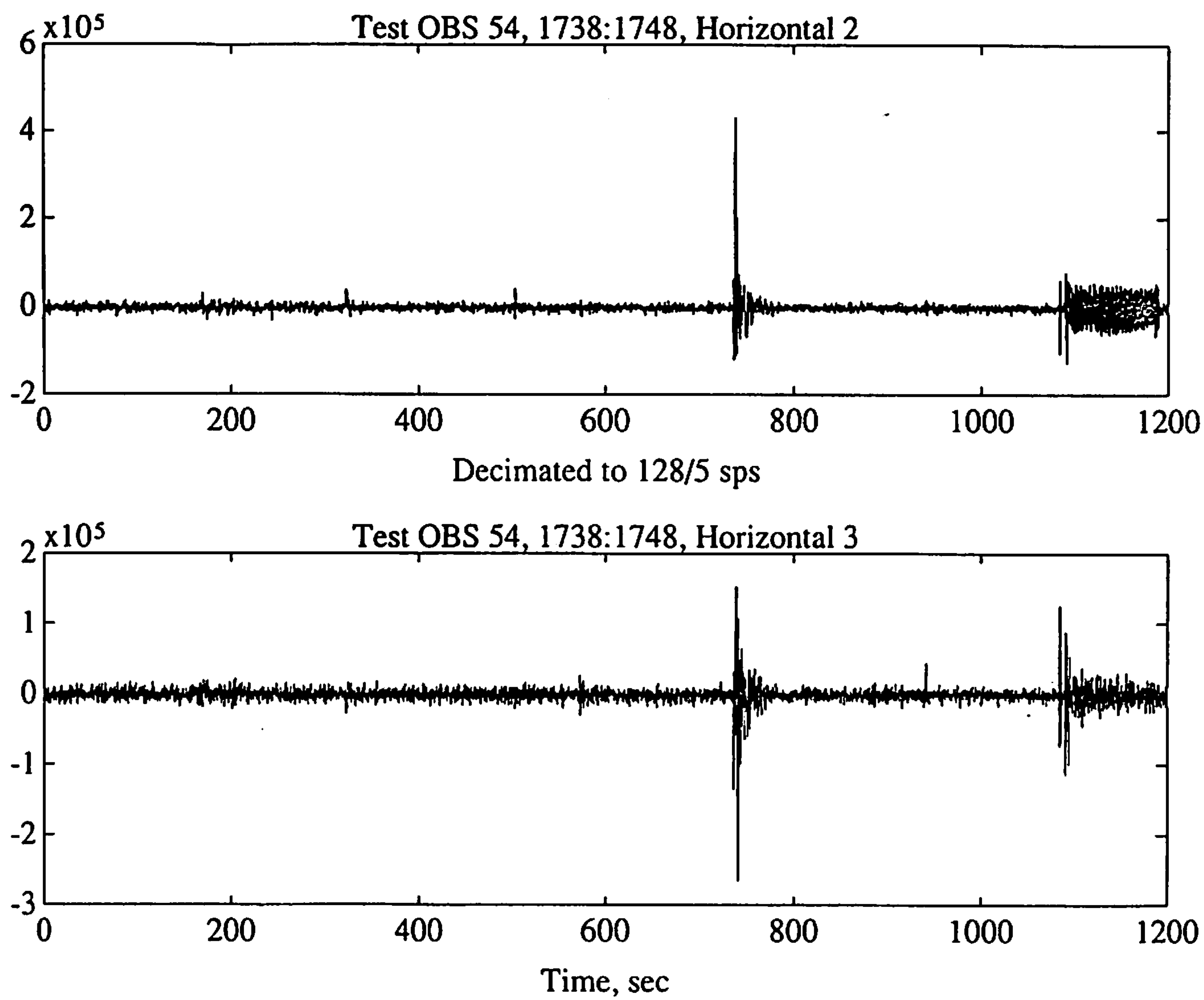


FIGURE A8.2b As Figure A8.2a except the two horizontal channels are shown here.

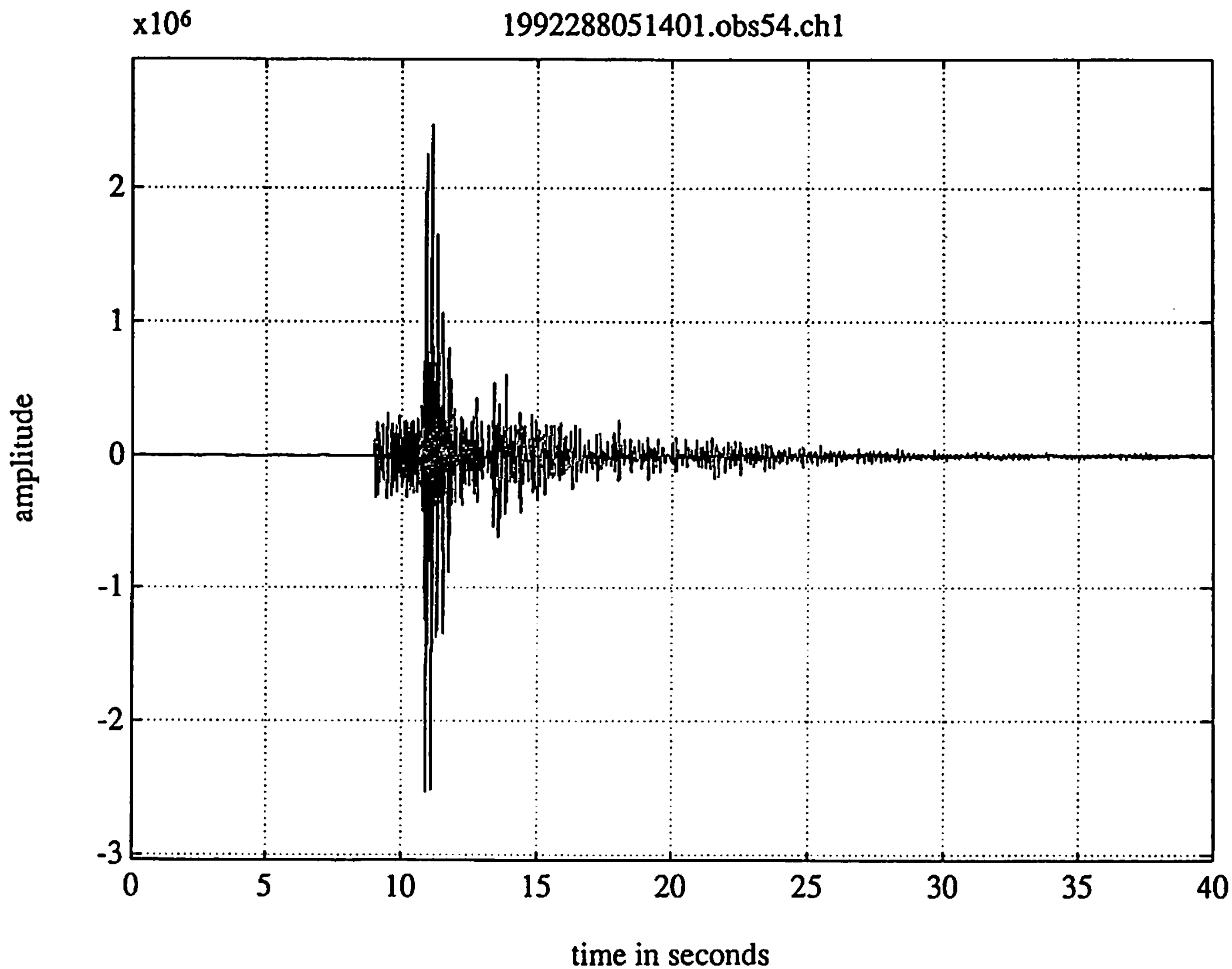


FIGURE A8.3 An example of a good event on the vertical seismometer channel recorded during the event detect phase of the deployment. The large second arrival is the shear wave: the P-S time is about 2 seconds.

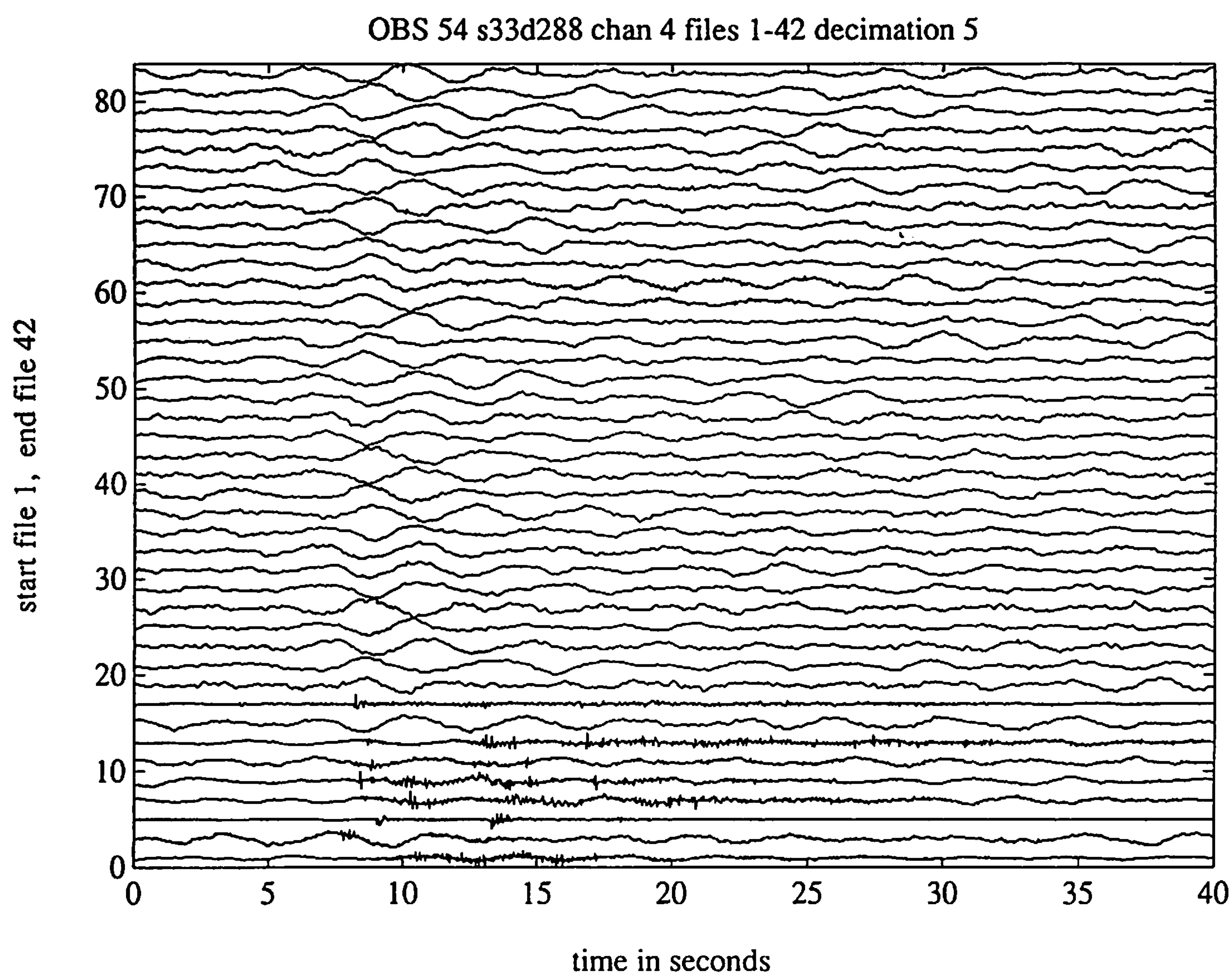


FIGURE A8.4 These 40 second long traces (that have been resampled and decimated by a factor of five to speed plotting) are the hydrophone records for all the events that triggered the OBS during the test deployment. Amplitudes have been arbitrarily scaled separately on each trace to produce the same maximum amplitude. The trigger occurs between 9 and 10 seconds.It is obvious that the majority are in fact spurious bursts of microseism noise.

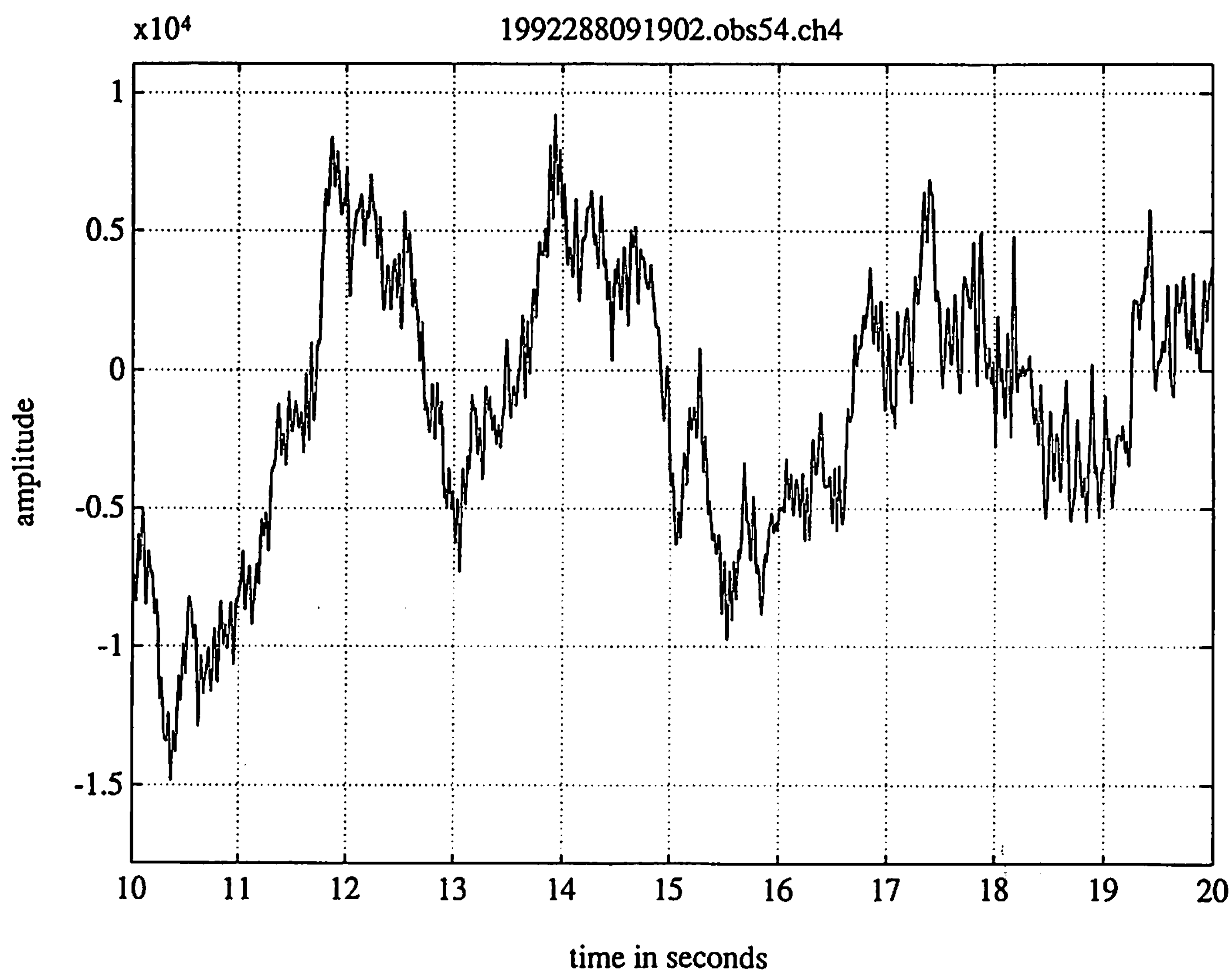


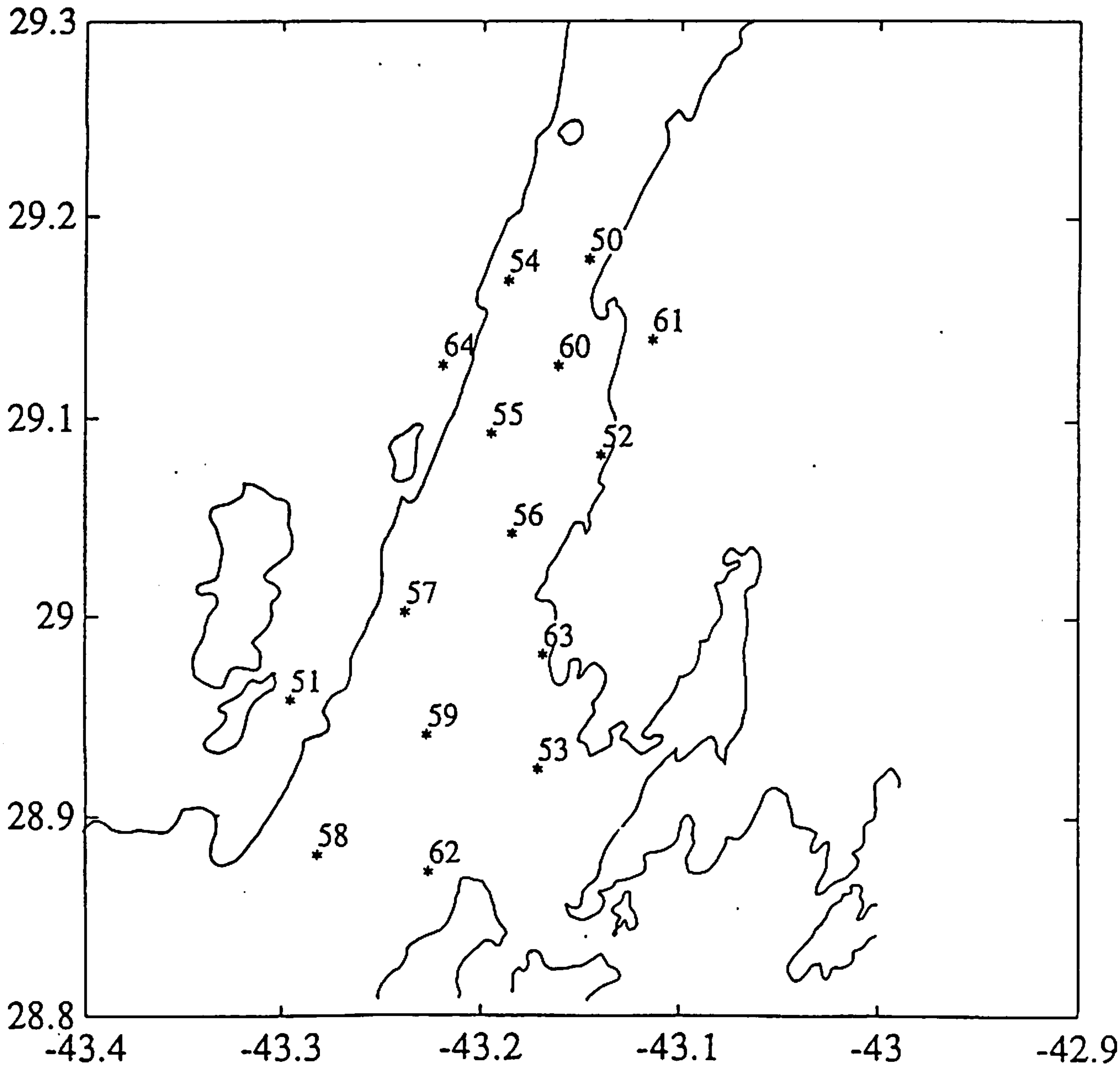
FIGURE A8.5 An example of ambient background noise on the hydrophone channel that shows the long period microseism energy with an amplitude of 2000-3000 counts (out of the A-to-D) upon which the higher frequency noise (just 100-200 counts) is superimposed.

Appendix 9 Examples of Good Data from FARA 01

On the following pages are a random sample of high quality seismograms recorded by the OBS instruments during the FARA 01 deployment. In all cases the raw unfiltered data are shown for all four channels that the units recorded. Examples from three different instruments are included. Most of the examples are of microearthquake recordings, but the record from one 60 lb explosive shot is also shown.

The string of numbers following the letter "e" in the title of each plot defines the absolute time of the zero time used for the plotting. The string consists of year (1992), Julian day (e.g. 237), hour, minute, second. In all cases no significance should be attached to the relative amplitudes between the traces: they have been arbitrarily scaled for the singular purpose of enhancing the plot.

The figure below shows the FARA 01 locations of the OBS's relative to the 3000m bathymetry contour that approximately delineates the median valley.



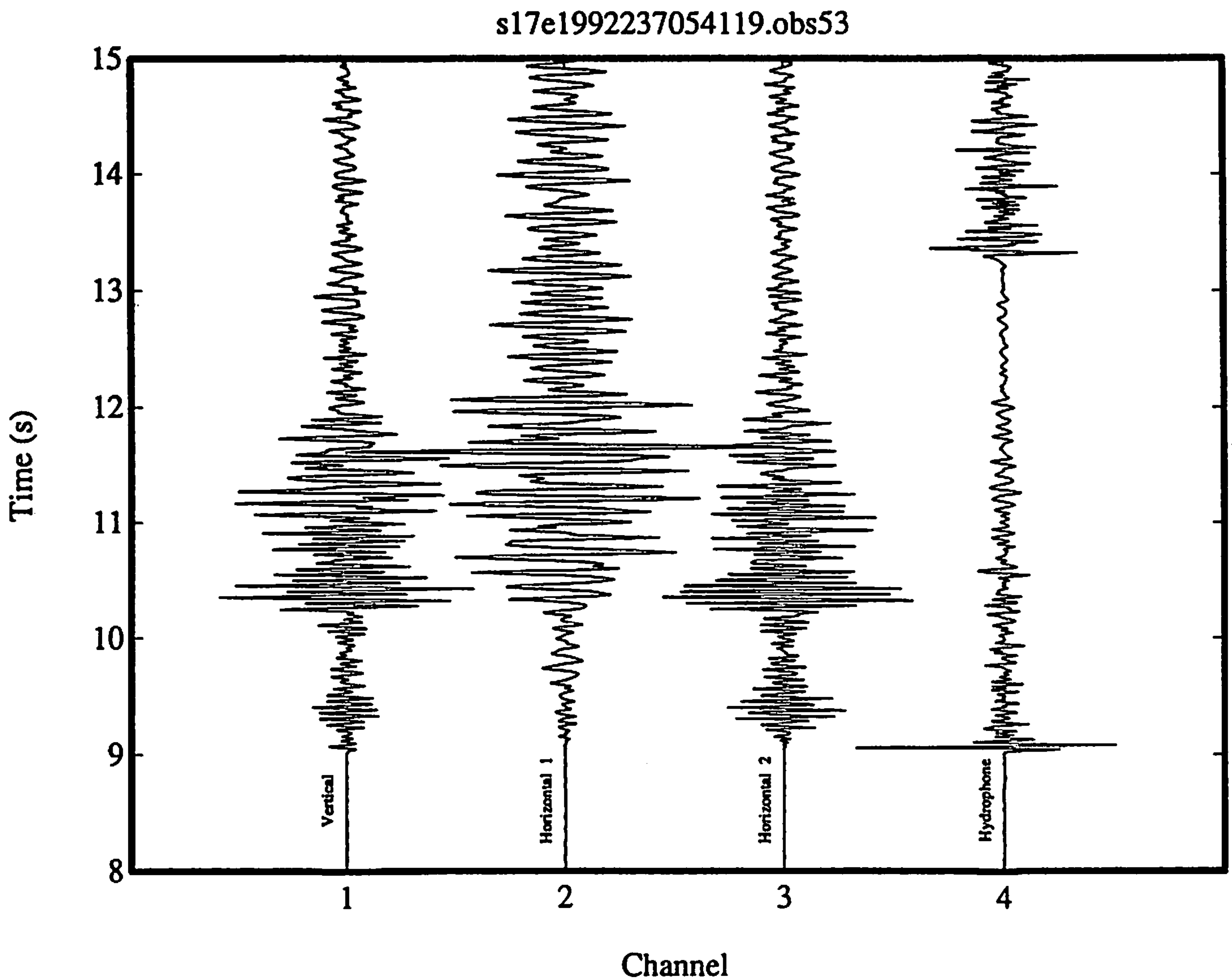


FIGURE A9.1 OBS #53 A near-by microearthquake generates impulsive first arrivals on the hydrophone and vertical seismometer channels. As can be seen the P-S time is a little over one second. Converted shear energy is nowhere recognizable on the hydrophone channel but clear S wave onsets are visible on the vertical and one of the horizontal channels.

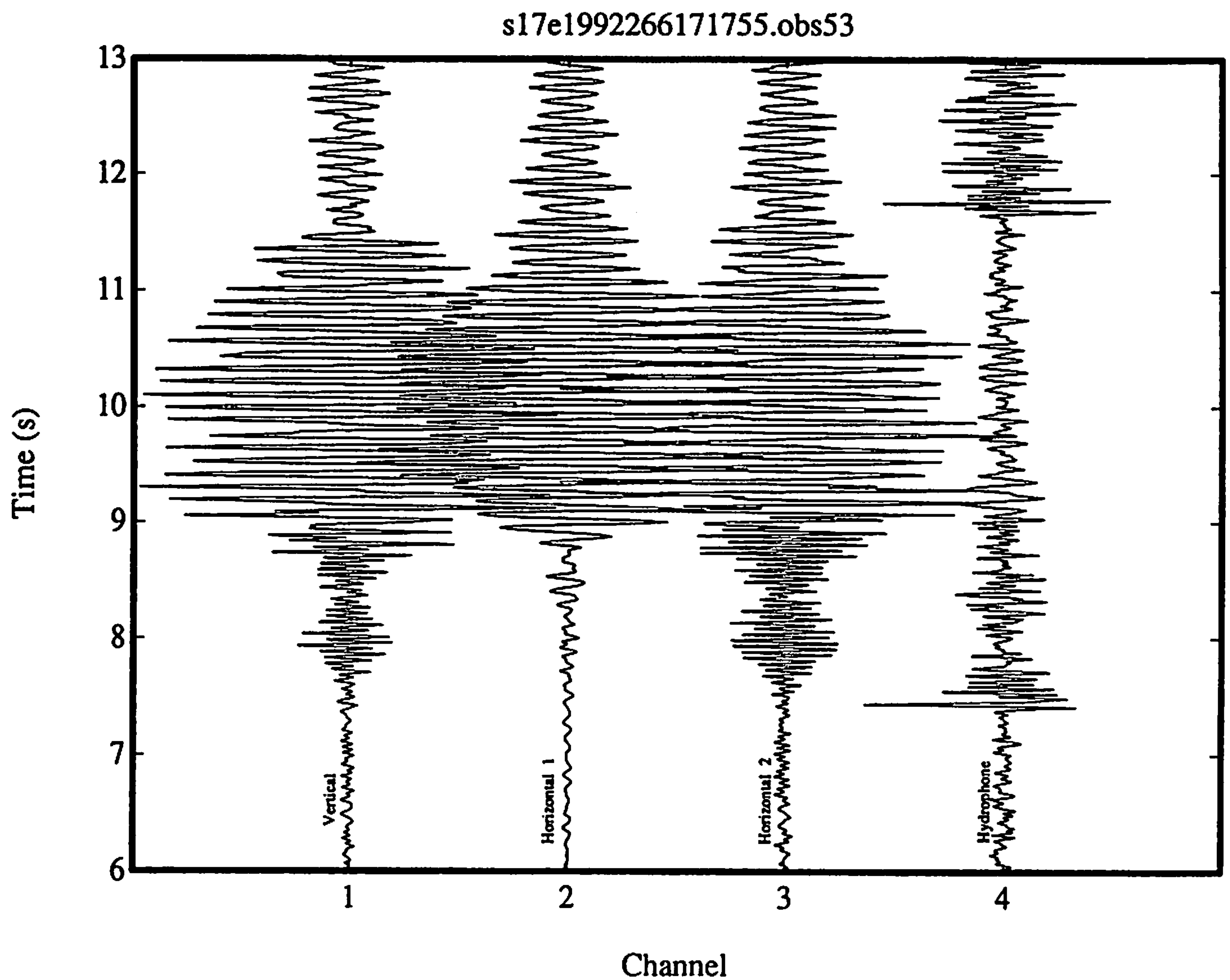


FIGURE A9.2 OBS#53 A smaller event than that shown in the previous figure but still with a clearly impulsive first break on the hydrophone channel.All three seismometer channels are characterized by monotonic signals.

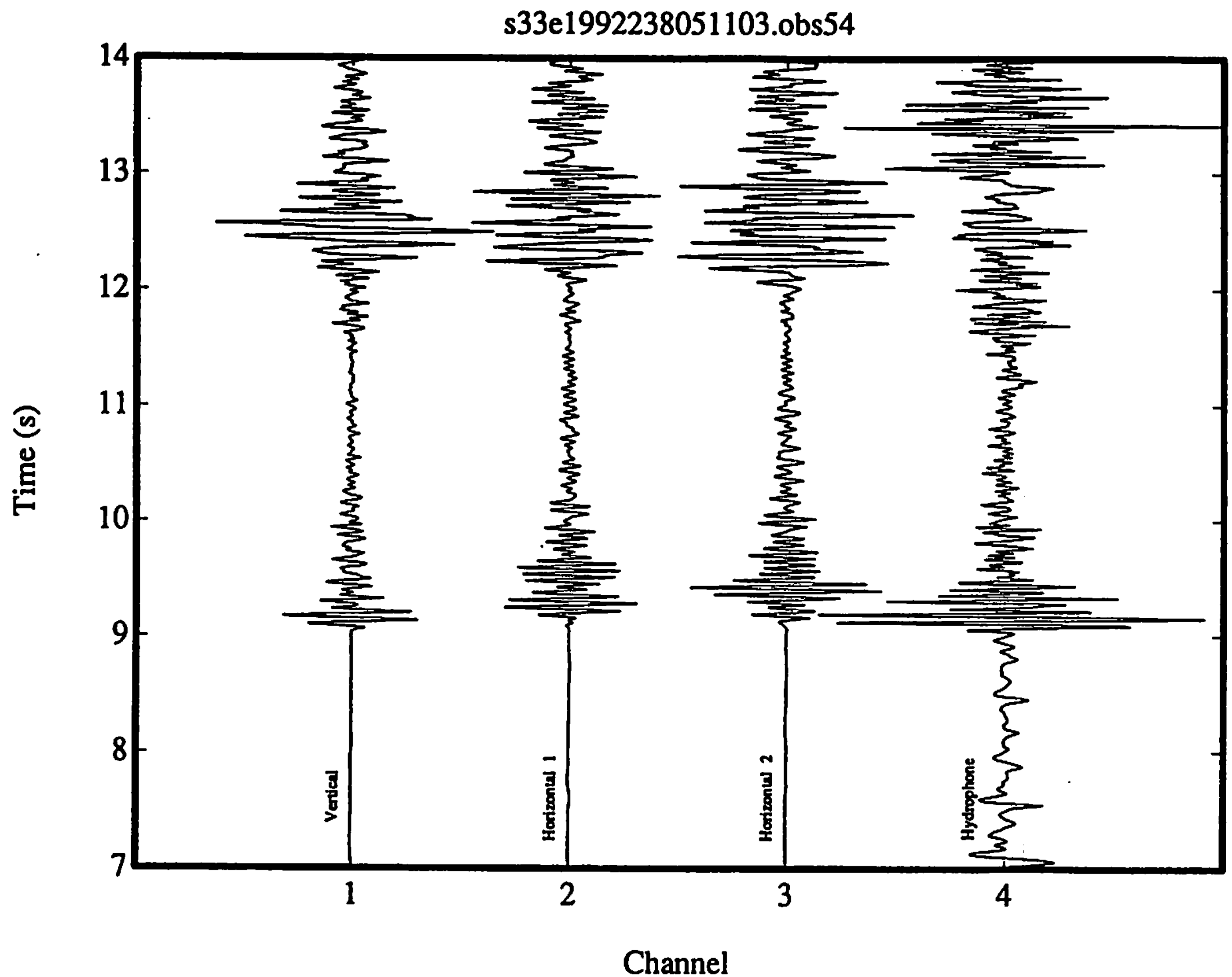


FIGURE A9.3 OBS#54 Clear first breaks are identifiable on all four channels but with a P-S time of approximately 3 seconds this is a reasonably distant event.

Appendix 10 New Check Lists

On the following 13 pages we include blank copies of the new checklists developed during this cruise to improve the quality of record keeping during OBS recovery and redeployment operations. This is not a compilation of all the check lists used for normal operations - just those newly developed or substantially modified during EW9210.

OBS LOG (page 2 of 2)

Cruise______________ Experiment______________ OBS #______________

Mechanical / Recovery Aids: **checks**

Balls ______________
Anchor ______________
EG&G Releases ______________
Air Acoustics ______________
9 KHz S/N______________ Reply______________KHz
11 KHz S/N______________ Reply______________KHz
Flag ______________
Radio S/N______________ Freq.______________MHz ______________
Flashers S/N______________ ______________ ______________
Foot Pad Weight ______________
Bunny Licks (facing sensor: left, right, both, none) ______________
Tilt indicator installed on sensor orb baseplate ______________
Corer installed on sensor orb ______________

Electronics:

Acquisition S/N______________ ______________
Seascan Clock S/N______________ ______________
Recorder S/N______________ ______________
Sensor Orb S/N______________ ______________
DPG S/N______________ ______________
Hydrophone S/N______________ ______________
Preamp S/N______________ ______________
Polyethylene pressure case mounts tightened ______________

Cabling:

DPG / EG&G Release to ACQ S/N______________ ______________
Hydrophone to Preamp S/N______________ ______________
Preamp to ACQ S/N______________ ______________
Sensor Orb to ACQ S/N______________ ______________
Serial Link S/N______________ ______________

Shore Power Dummy on REC ______________
Second Dummy on REC ______________

OBS Aquisition Preparation Checklist

Cruise______________ **Experiment**______________ **OBS #**______________

Acquisition S/N______________ **checks**

Change Seascan clock battery		______________
Check and clean O-rings		______________
Board check and inventory		______________
Check / Replace zincs		______________
Assemble		______________
Purge ____ times	________lbs	______________
Pull final vacuum	________in. Hg	______________

OBS Recorder Preparation Checklist

Cruise_______________ Experiment_______________ OBS #_______________

Recorder S/N_______________ **checks**

Label disk (Side A B)		_______________
Insert disk		_______________
Battery check	__________ __________ __________	_______________
Check and clean O-rings		_______________
Board check and inventory		_______________
Check / Replace zincs		_______________
Assemble		_______________
Purge ____ times	________lbs	_______________
Pull final vacuum	________in. Hg	_______________

29 Aug 92

OBS Sensor Orb Preparation Checklist

Cruise______________ **Experiment**______________ **OBS #**______________

Sensor Orb S/N______________

	checks
Seismometers connected	______________
Resonant frequency test (1 +/- 0.10 Hz)	______________
Levelling test	______________
Centering test	______________
Electronics gain test	______________
Check and clean O-rings	______________
Check / Replace zincs	______________
Assemble	______________
Visual check	______________

Acquisition Configuration

Date__________ Cruise______________ Deployment____________

Acquisition Serial Number________________________

Seascan Clock	S/N ____________
RAM-2M	S/N ____________
CPU8088	S/N ____________
Serial Link	S/N ____________
PAR-40	S/N ____________
QDART	S/N ____________
SAIL-EE	S/N ____________
STB	S/N ____________
Digital AGC 1	S/N ____________
Digital AGC 2	S/N ____________
C44 A/D	S/N ____________
Analog A/D	S/N ____________
Analog AGC 1	S/N ____________
Analog AGC 2	S/N ____________
Analog AGC 3	S/N ____________
Analog AGC 4	S/N ____________
Analog AGC 5 & Notch	S/N ____________
Analog ACC 6 & Notch	S/N ____________
4-Pole Filter	S/N ____________
DPG Preamp	S/N ____________
HFD (water wave)	S/N ____________

29 Aug 92

Recorder Configuration

Date__________ Cruise______________ Deployment____________

Recorder Serial Number________________________

Power Regulator S/N ____________________

Mem64 S/N ____________________

CPU8088 S/N ____________________

SAIL/Serial Link S/N ____________________

A to D S/N ____________________

C44 to SCSI Interface S/N ____________________

RAMBLE #1 S/N ____________________

RAMBLE #2 S/N ____________________

RXT-800-S (Maxtor) S/N ____________________

Utility S/N ____________________

Predeployment Record (page 1 of 2)

Date______________ Acquisition pkg S/N______________

OBS Frame No.______________ Recorder pkg S/N______________

Clock S/N______________

SETUP SEQUENCE

- Main power supplies on ______________
- Short SAIL ______________
- Attach stations (first over is last on loop) ______________
- Unshort SAIL ______________
- Configure loop (powers all instruments) ______________
- Select loop ______________

PRELIMINARY CHECKS

- Start PROCOMM, open log file______________ ______________
- Address acquisition ______________
  - Version, status ______________
  - Timer menu (t, Z, n=6, exit) ______________
- Address recorder ______________
  - Version, status ______________
  - Disk init OK ______________

POWER SWITCHOVER

- Battery switch on(last inst. in loop) ______________
- Recorder still addressed ______________
- Exit PROCOMM ______________
- Shore Power Off ______________
- Start PROCOMM, open log file______________ ______________

DISK TEST

- Address recorder ______________
  - Prepare to write, 'g' etc. ______________
- Address acquisition ______________
  - Collect 1 minutes of data ______________
- Address recorder ______________
  - Check disk write OK ______________
  - Update Directory(Ender) ______________
  - Read data, file name______________ ______________
- Exit PROCOMM

Predeployment Record (page 2 of 2)

PROGRAMMING

Reset both packages ________
Start PROCOMM, open log file________ ________
Address recorder ________
  Initialize disk ________
  Voltages ________
  'go' ________
Address acquisition ________
  Enable Qdarts ________
  Set Gains ch1____ch2____ch3____ ________
  Disable Qdarts ________
  Event menu ________
  Set thresholds ________
   ch1_____ ch2_____ ch3_____ ch4_____
  Set period ________
  Set Max ________
  Set Lockout ________
  Status ________
  Clock menu, start BIGTIME at ________ ________
  Open loop to SAILCLOCK ________
  Grab two BIGTIMEs, then '#' ________
  Alt F4 convert bigtime ________
  using bigt. ________
  Change baud rate, alt P, 5 ________
  Short/unshort loop to wake Seascan ________
  Read Seascan clock twice ________
  SAILCLOCK ?L, !L, R, L, !S, # ________
  Short loop to SAILCLOCK ________
  Change baud rate, alt P, 11 ________
  Schedule menu, load schedule files ________
    ________.sk1
    ________.sk2
    ________.sk3
  Check schedules, 'p' operation, then 'V' ________
  'e', then 's' ________
  Close, check log file ________
  Unaddress '#' ________
  Short Sail loop, remove station, time? ________

October 30, 1992

PROGRAMMING RECORD

Experiment______________________________ **DATE**____________________

WINDOWED RECORDING:

	SCHEDULE 1.1	SCHEDULE 1.2	SCHEDULE 1.3
START TIME			
DURATION			
INTERVAL			
NO. OF WINDOWS			
FILE NAME			

EVENT RECORDING.

	SCHEDULE 2.1	SCHEDULE 2.2	SCHEDULE 2.3
START TIME			
STOP TIME			
PRECURSOR			
TOTAL LENGTH			
TRIGGER CHANNEL			
THRESHOLD			
MAXIMUM COUNT			
PERIOD			
FILE NAME			

CALIBRATION RECORDING

	SCHEDULE 3.1	SCHEDULE 3.2	SCHEDULE 3.3
START TIME			
DURATION			
INTERVAL			
NO. OF CHANNELS			
FILE NAME			

OBS HARDWARE RECOVERY LOG

Cruise_______________ **Experiment**_______________ **OBS #**_______________

Mechanical / Recovery Aids: **checks**

Balls _______________

EG&G Releases (released and disabled?)

9 KHz S/N_______________ _______________

11 KHz S/N_______________ _______________

Flag (upright?) _______________

Radio S/N_______________ _______________

Flashers S/N_______________ _______________ _______________

Tilt indicator (orientation re: sensor bail, degrees CCW) _______________

Corer (sediment / no sediment) _______________

Corrosion _______________

Sensor arm re-engaged _______________

Cabling:

Connector status (pins checked in lab) _______________

Comments:

____

____

____

____

____

____

Postrecovery Record (Page 1 of 2)

Experiment________________

Date______________ | Acquisition pkg S/N______________
OBS Frame No.______________ | Recorder pkg S/N______________
Sensor pkg S/N______________ | Clock S/N______________

DECK CHECKS

- Corer sediment _____YES _____NO ______________
- Sensor level rust spot ______________
  - Center _____YES _____NO
  - Tilt angle________ Orientation________
- Frame level rust spot ______________
  - Center _____YES _____NO
  - Tilt angle________ Orientation________

SETUP SEQUENCE

- Main power supplies on ______________(Use Grey box,
- Grey Box Power Switch off ______________100' black cable).
- Short Instrument and SAIL Clock SAIL Loops ______________
- Attach Cable to Instrument ______________
- Start PROCOMM, open log file______________ ______________
- Unshort Instrument SAIL Loop ______________

POSTRECOVERY CHECKS

- 'Address acquisition ______________
  - Running OK ______________
  - STUCK value ______________
  - Open loop to SAILCLOCK ______________
  - Display status (main menu, s) ______________
  - Grab two BIGTIMEs, then '#' ______________
  - Change baud rate, alt P, 5 ______________
  - Read Seascan clock twice ______________
  - SAILCLOCK ?L, !E,R, L, !S, # ______________
  - Short loop to SAILCLOCK ______________
  - Change baud rate, alt P, 11 ______________
- Confirm recorder unaddressed ______________
- Exit PROCOMM (alt F4) ______________
- Check PROCOMM log file ______________
- Reset both packages ______________
- Start PROCOMM, open log file______________ ______________
- Address recorder ______________
  - Errors, voltages, messages ______________
  - Disk init OK ______________
  - Update directory entry ______________
  - Start LBA__________ End LBA__________
  - Delta LBA__________hex, __________decimal
  - Total data recorded (bytes)______________decimal
  - Dump recorder and acquisition memories. ______________
  - MAXTOR power off (P) ______________

October 26, 1992

Postrecovery Record(Page 2 of 2)

Experiment______________

If full disk postpone reading or collecting data until after mem dump.

Address acquisition ______________

Collect 30s of data(only if memory dumped) ______________

Data file name____________________

Exit PROCOMM ______________

POWER SWITCHOVER(only if memory dumped)

Shore power on ______________

Battery switch off ______________

DATA EVALUATION(only if memory dumped)

Read from LBA____________ to LBA_____________

Result____

____

Hardcopy ____________

October 26, 1992

OBS TRANSCRIPTION LOG

Date______________ Acquisition pkg S/N______________

OBS Frame No.______________ Recorder pkg S/N______________

Sensor Orb S/N______________ Clock S/N______________

Cruise______________ Experiment______________

Deployment Dates______________________________

MAXTOR Start LBA______________hex ______________dec

Finish LBA______________hex ______________dec

Blocks Transcribed______________x 2048 ______________bytes

Tape__________ of __________

COMMENTS (include information such as format, command used, path and filename if doing a preliminary transcription to hard disk, etc...)

____

____

____

____

____

____

____

____

____

____

____

____

____

____

29 Aug 92

Appendix 11 Mechanical Modifications to the ONR OBS

Some of the problems encountered during the FARA 01 deployment, namely the failure of the recorder to write to disk despite repeated attempts, and the deployment of the sensor package on its side, were hypothesized to be caused by extremely steep topography. It is supposed that the sensor package was being deployed while the frame was in motion down slope. This supposition is supported by the fact that the sensor packages came to rest in many different orientations, which are difficult to explain in terms of the sensor deployment mechanism alone.
(see Table ? in Appendix ??) Further, the failure to write to disk is hypothesized to have been caused by the frame resting at a tilt angle greater than fifteen degrees on its long axis.

In an attempt to deal with the problems described above, new systems for mooring the frame and releasing the sensor were devised and tested during a 24 hour deployment (FARA 2-TEST).
RSLIs mounted on the sensor package and the frame, indicated that the sensor was properly deployed, and both frame and sensor had minimal tilt angles. Modifications to the instruments are described below.

MOORING SYSTEM

By floating the frame just above the bottom, the symmetrical flotation on the package assured reasonable orientation, unless the anchor tether constrained its freedom to level itself. It was decided that tilt on the frame's short horizontal axis was acceptable, since it simplified mooring design, and the Maxtor could still write when tilted in that direction. Any useable anchor design also had to limit the frame's rotation about its vertical axis since this could lead to entanglement of the anchor and sensor tethers, and prevent recovery. It was decided to build a mooring system that would provide frame leveling on the long axis at bottom slopes of up to 30 degrees (see Figure A11.1).

The mooring utilized a standard ONR OBS plate anchor, with an eye welded onto its upper face at each corner. Some anchor lines were fabricated from 3/16" hydrographic wire, others from 3/16" chain, and attached to the eyes. Their length of 22" gave the frame enough height to clear a 30 degree slope. The two lines from each side of the anchor were attached to one end of a 36" long strength member (in this case 2" Schedule 80 pipe),across the bottom of the frame, which was secured to the release drop bar via the drop ring and a large shackle. The strength member was kept perpendicular to the frame's long axis by tension on the drop ring and by blocking attached to the bottom of the frame. (Figure A11.2)

SENSOR DEPLOYMENT

Since the new mooring system suspended the frame above the sea floor, the bottom contact foot previously used to release the sensor was inoperative. Each sensor was released via the use of two soluble links made of sugar. These links were similar to those used for OBS sensor release by MIT. Their data indicated that release times could be varied by changing the lengths of the links. A link of 2" length was used to release the sensor deployment arm; one of 3" length released the sensor from the arm. The 2" link dissolved in approximately 3-3/4 hours; the 3" released about 1 hour later. It is hoped that this sensor release system allows the sensor to be deployed on the bottom with a range of frame-to-bottom distances. It should also eliminate problems caused by release of the sensor while the frame is moving or adjusting to uneven terrain.

SENSOR BASE PLATE MODIFICATIONS

Several different sensor base plate configurations were considered. Two prototypes were built that utilized three legs, giving true three-point bottom contact. Observation indicated that legs long enough to provide any leveling advantage in sizable relief, would greatly increase the chances of the sensor falling onto its side. Ultimately the only change made to the base plate was the elimination of one of the angle brackets on its bottom and the relocation of two others to yield three equally spaced brackets.

SENSOR BLOCK INSULATION

The entire sensor block was isolated from the pressure sphere by installing insulation at the sensor pivot support block (see Figure A11.3). A mylar shim was installed between the sensor block support arm and the inner pivot support block. The cap screws which hold the two together, were isolated from the sensor block support arm by inserting nylon washers under the heads and covering the upper shanks with shrink tubing. (see Figure A11.4)

POSSIBLE CHANGES

The modifications made to the ONR OBS during this cruise were necessarily constrained by availability of materials aboard the EWING, and by need to keep existing hardware in tact. (e.g. the sensor bail might have been a more convenient shape for attaching sugar releases, but we lacked time and material to modify it.) If it were decided to use a similar mooring system on future deployments, changes could be made which would make it easier to work with and perhaps better at leveling the frame and sensor.

The anchor line strain member across the bottom of the frame would be better made from robust flat stock or channel. This would keep it from making contact with the deck. The pipe used on this deployment created the need to block the frame off the deck during and after installation.

The anchor drop ring needs to be changed so that the need for the large shackle is eliminated. This is simply a matter of lengthening the threaded portion, or building up an attachment point on the strain member.

The inverted channel on the anchor is no longer required.

A retainer to keep the strain member in place on the frame rails needs to be designed and attached to the frames. It should be built so that it won't protrude below the the frame feet. This part would replace the blocks shown in the figure.

A system could be easily designed which would allow the flotation to level the frame on both horizontal axes. Such a mooring system would, however, need to take into consideration factors of tether entanglement, and ease of rigging and launching.
Sugar releases seem to be a reliable and simple form of roughly- timed release. Small modifications to the sensor deployment arm and the sensor bail would make their installation simpler and more reliable.

More thought should be given to sensor base plate design for deployment on uneven terrain.

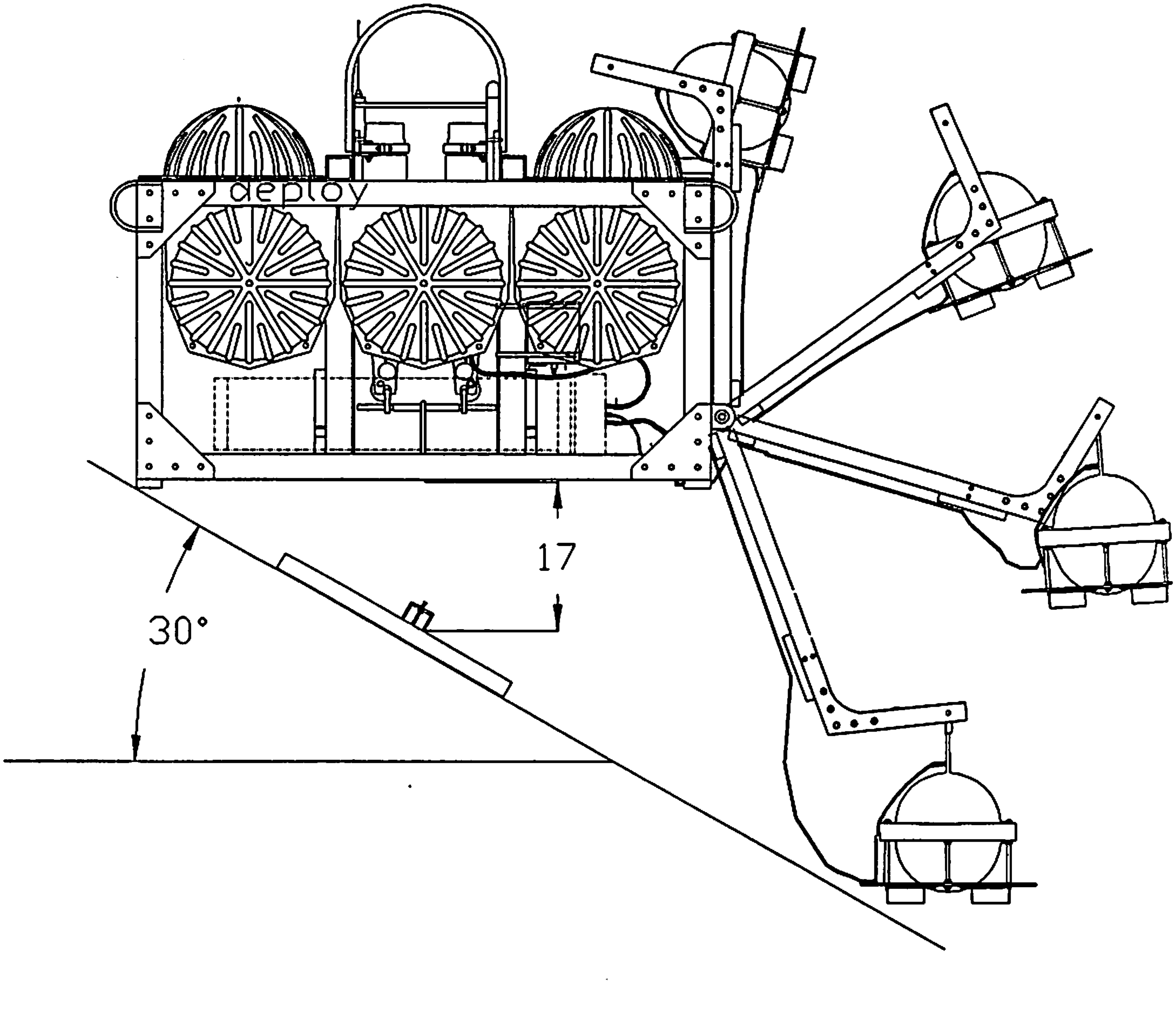


FIGURE A11.1 A scale drawing that shows the relationship of an OBS (modified to float above the seafloor) and its deployable package, with a seafloor sloping at 30 degrees. The design goal for the shipboard modifications was to allow the instrument to function under these conditions.

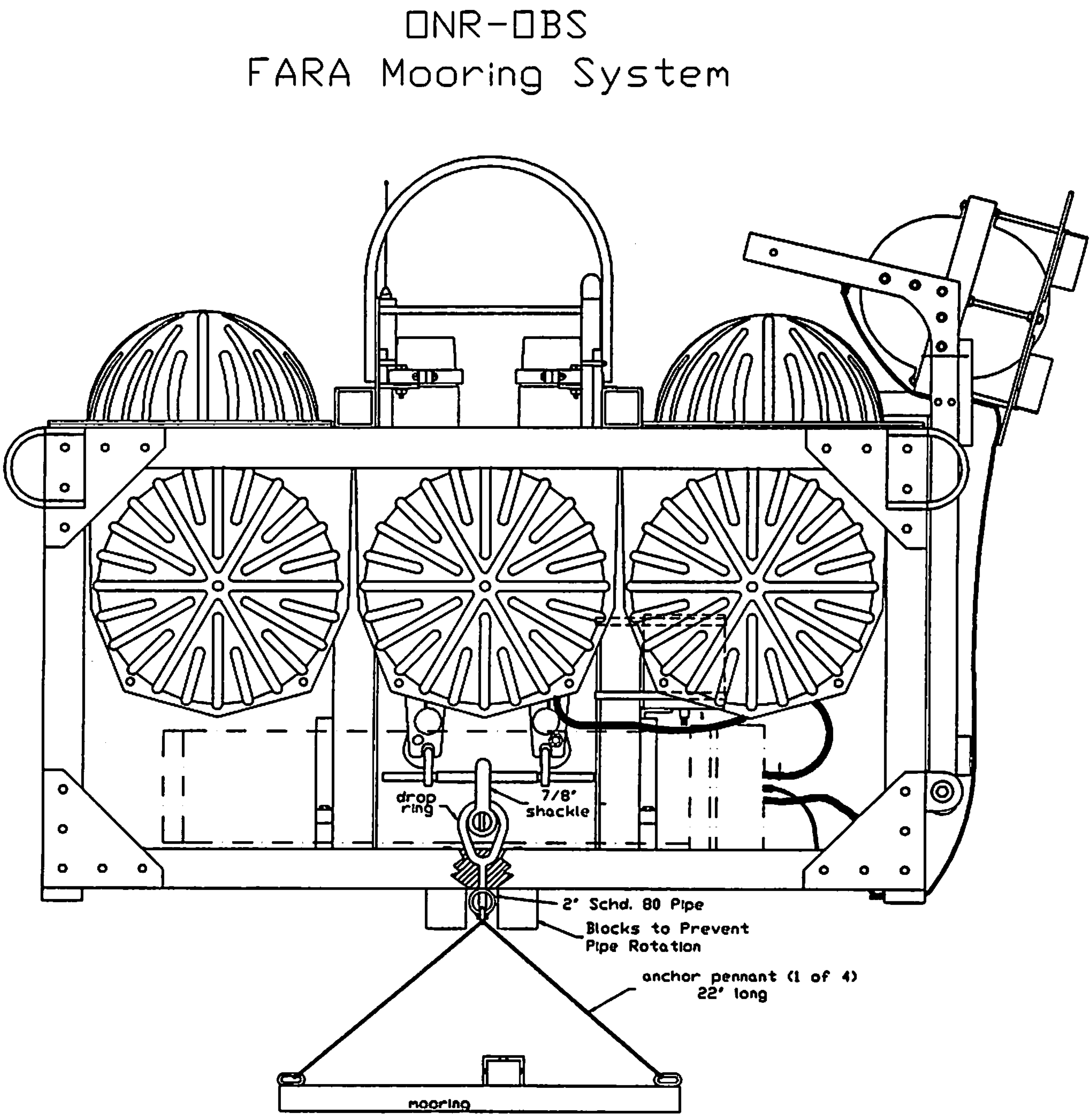


FIGURE A11.2 A scale drawing of the details of the anchor modifications that allow the OBS to float approximately 17 inches above the seafloor and maintain itself level on its longitudinal axis.

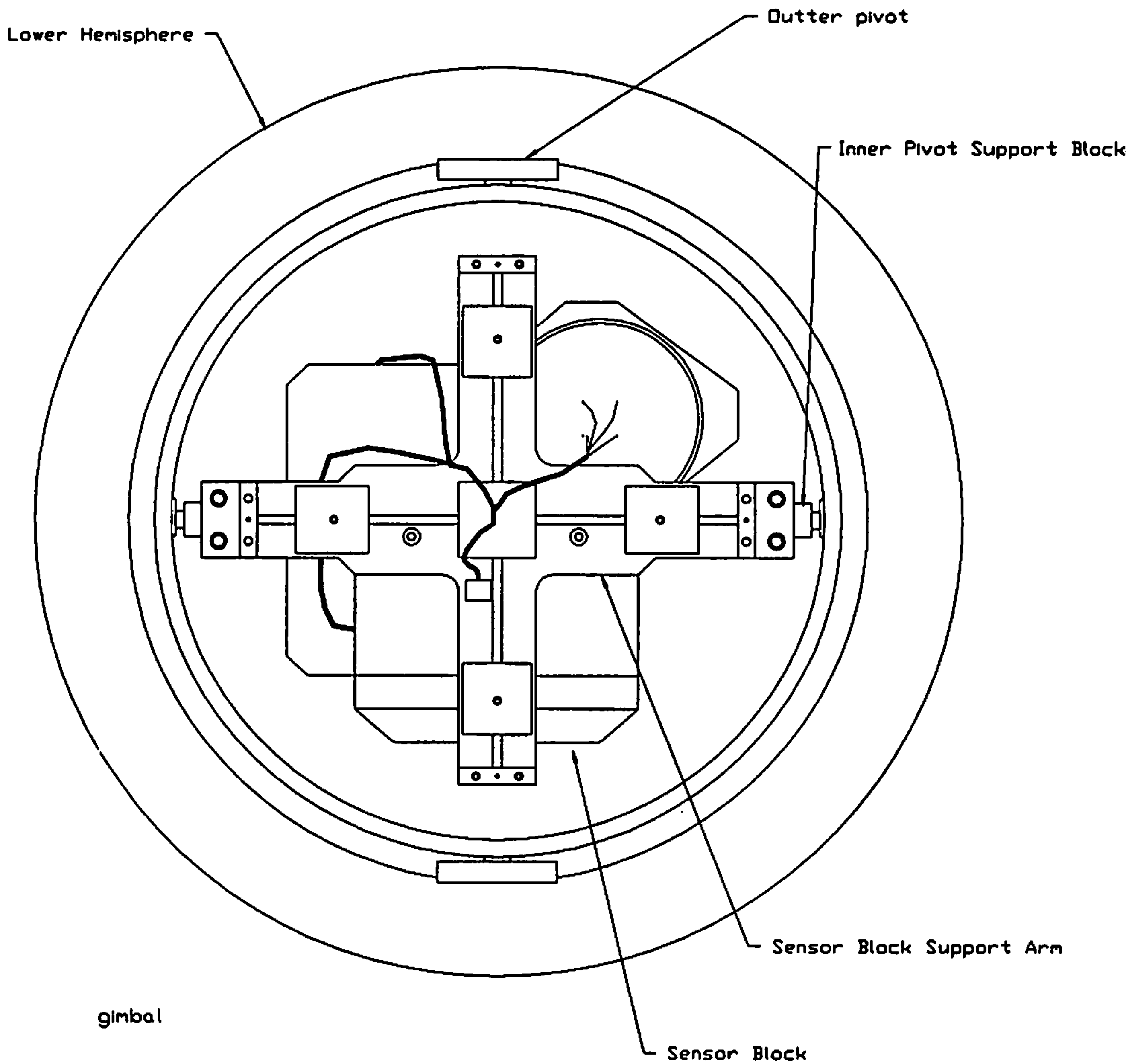


FIGURE A11.3 A plan view of the interior of the external sensor package to help illustrate where the insulation was located that isolated the sensor block from the pressure case.

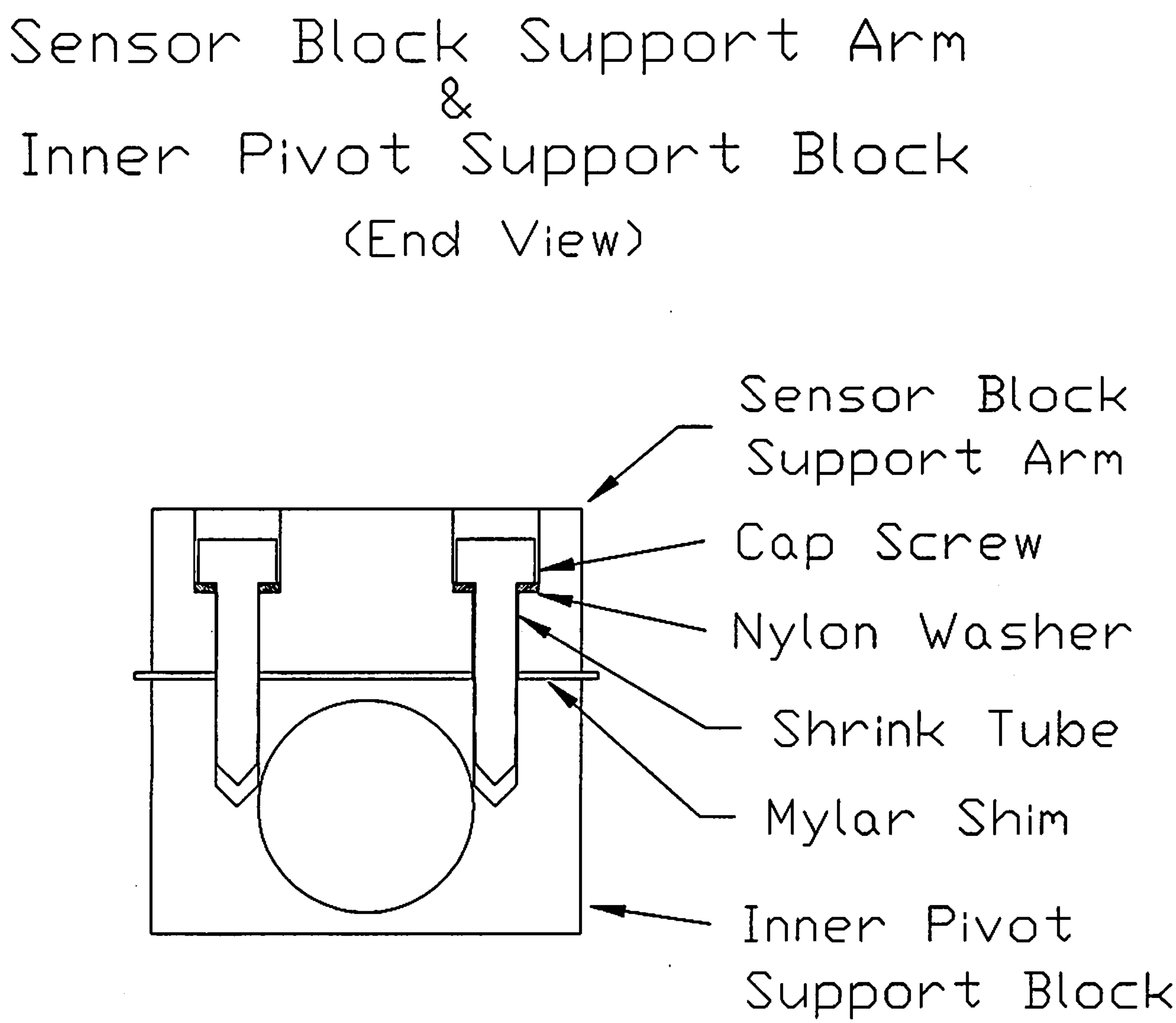


FIGURE A11.4 Detailed location of insulation on the sensor pivot support block.

Appendix 12 Acquisition Programs FARA.01&FARA.02

Data acquisition for the deployment FARA.01 was controlled according to the schedule below:

Event Detection mode using the **hydrophone** sensor	Start:	1400Z** 22nd Aug (235)
	End:	1155Z 16th Sept (260)
Event Detection mode using the **vertical** seismometer	Start:	1200Z 16th Sept (260)
	End:	1155Z 2nd Oct (276)
Continuous Recording	Start:	1200Z 2nd Oct (276)
	End:	0955Z 4th Oct (278)
Seismometer Calibration	Start:	1000Z 4th Oct (278)
	End:	1006Z 4th Oct (278)

The event detection threshold for the ratio of the short term to the long term average was set to 3.

The maximum number of events permitted within any four hour period was set to 35.

The total event length was 40 seconds, including 10seconds recorded prior to the event itself.

** = On OBS 50, 61, 60 and 54 this start time was set to 1700Z 22nd August.

Data acquisition for the deployment FARA 02 was controlled according to the schedule below:

JDAY

Continuous Recording:	**START:**	**2100Z 2nd Nov**
	END	**2100Z 3rd Nov**
Event Detect {Hydrophone}	**START**	**2105Z 3rd Nov**
ThresholdSTA/LTA=3	**END**	**0555Z 7th Dec**
Lockout = 25 per four hours		
Event Detect {Vertical}	**START**	**0600Z 7th Dec**
ThresholdSTA/LTA=7	**END**	**0555Z 17th Dec**
Lockout = 25 per four hours		
Continuous Recording	**START**	**0600Z 17th Dec**
	END	**0555Z 19th Dec**
Calibrations	**START**	**0600Z 19th Dec**
	END	**0606Z 19th Dec**

357

As in FARA 01 the total event length was 40 seconds

Appendix 13 FARA 01 Shot Table and Location Figures

(Shot numbers for 60 lb charges are bold, remainder are 6lb shots)

OBS SHOT	64	63	61	59	58	57	56	54	53	51	50	#
1	X	X	X	X	X	X	X	X	X	X		10
2	X	X	X	X	X	X	X	X	X	X		10
3	X	X		X	X	X	X	X	X	X		9
4		X		X	X	X	X	X	X	X		8
5		X		X	X	X	X	X	X	X		8
6		X			X	X	X	X	X	X		7
7		X			X	X	X	X	X	X		7
8		X			X	X	X			X		5
9	X	X	X	X	X	X	X			X		8
10	X	X	X	X	X	X	X		X	X		9
11	X	X		X	X	X	X		X	X		8
12	X	X		X	X	X	X	X	X	X		9
13		X		X	X	X	X	X	X	X		8
14		X		X	X	X	X	X	X	X		8
15		X		X	X	X	X	X	X	X		8
16		X		X	X	X	X	X		X		6
17	X	?	X	X	X	X	X	X	X	X		10
18	X	X	X	X	X	X	X	X	X	X		10
19	X	X	X	X	X	X	X		X	X		9
20											*bad*	*shot*
21		X	X	X	X	X	X	X	X	X		9
22		X		X	X	X	X	X	X	X		8
23	X	X			X	X	X	X	X	X		8
24											*bad*	*shot*
25	X	X	X	X	X	X	X	X	X	X		10
26	X	X	X	X	X	X	X	X	X	X		10
27	X	X	X	X	X	X	X	X	X	X		10
28	X	X	X	X	X	X	X	X	X	X		10
29	X	X	X	X	X	X	X	X	X	X		10
30	X	X	X	X	X	X	X		X	X		9
31	X	X	X	X	X	X	X	X	X	X		10
32	X	X	X	X	X	X	X	X	X	X		10
33		X		X	X	X	X	X	X	X		8
34	X	X			X	X	X	X	X	X		8
35	X	X	X		X	X	X	X		X	X	9
36	X	X	X	X	X	X	X			X	X	9
37		X	X	X	X	X	X			X		7
38		X	X	X	X	X	X			X	X	8
39		X		X	X	X	X		X	X	X	8
40		X		X	X	X	X		X	X	X	8
41		X		X	X	X	X	X	X	X	X	9
42		X			X	X	X	X	X	X	X	8
43		X			X	X	X	X	X	X	X	8

OBS SHOT	64	63	61	59	58	57	56	54	53	51	50	#
44		X			X	X	X		X	X		6
45	X	X			X		X	X		X	X	7
46	X	X			X	X	X			X		6
47		X	X	X	X	X	X		X	X	X	9
48		X	X	X	X	X	X		X	X	X	9
49		X	X	X	X	X	X	X	X	X	X	10
50		X			X	X	X	X	X	X	X	8
51		X			X	X	X	X	X	X	X	8
52		X			X	X	X	X	X		X	7
53	X	X			X	X	X			X	X	7
54	X	X			X	X	X			X		6
55		X	X	X	X	X	X			X		7
56		X	X	X	X	X	X			X		7
57		X		X	X	X	X			X		6
58		X		X	X	X	X			X		6
59		X			X	X	X		X	X		6
60		X			X	X	X	X	X	X		7
61		X			X	X	X	X	X	X		7
62		X			X	X	X	X		X		6
63		X			X	X	X	X		X		6
64		X	X	X	X	X	X			X		7
65		X	X	X	X	X	X			X		7
66		X	X	X	X	X	X			X		7
67		X	X	X	X	X	X			X		7
68		X	X	X	X	X	X	X		X		8
69		X		X	X	X	X	X		X		7
70		X			X	X	X	X		X		6
71		X				X	X	X		X		5
72		X				X	X	X		X		5
73	X	X				X		X		X		5
74	X	X				X						3
#	28	72	30	45	68	71	70	45	44	70	16	559

The "x" marks in the tables above define which shots generated recorded events on which OBS's. Simple cartoon views of the spatial distribution of these shots, for each receiver, are presented in the following figures.

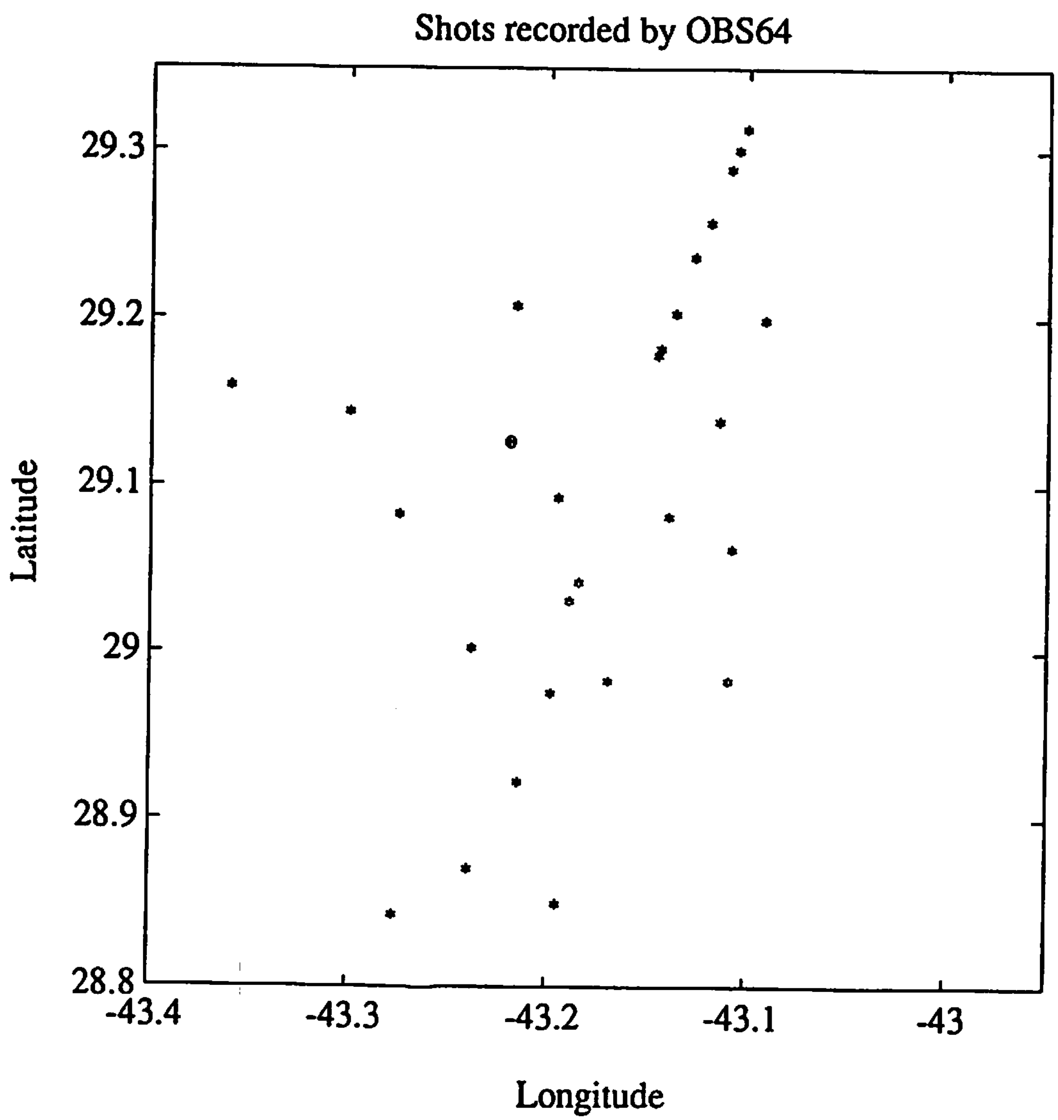


FIGURE A13.1 Locations of the explosive shots (asterisks) recorded by OBS 64 relative to the location of the OBS (open circle).

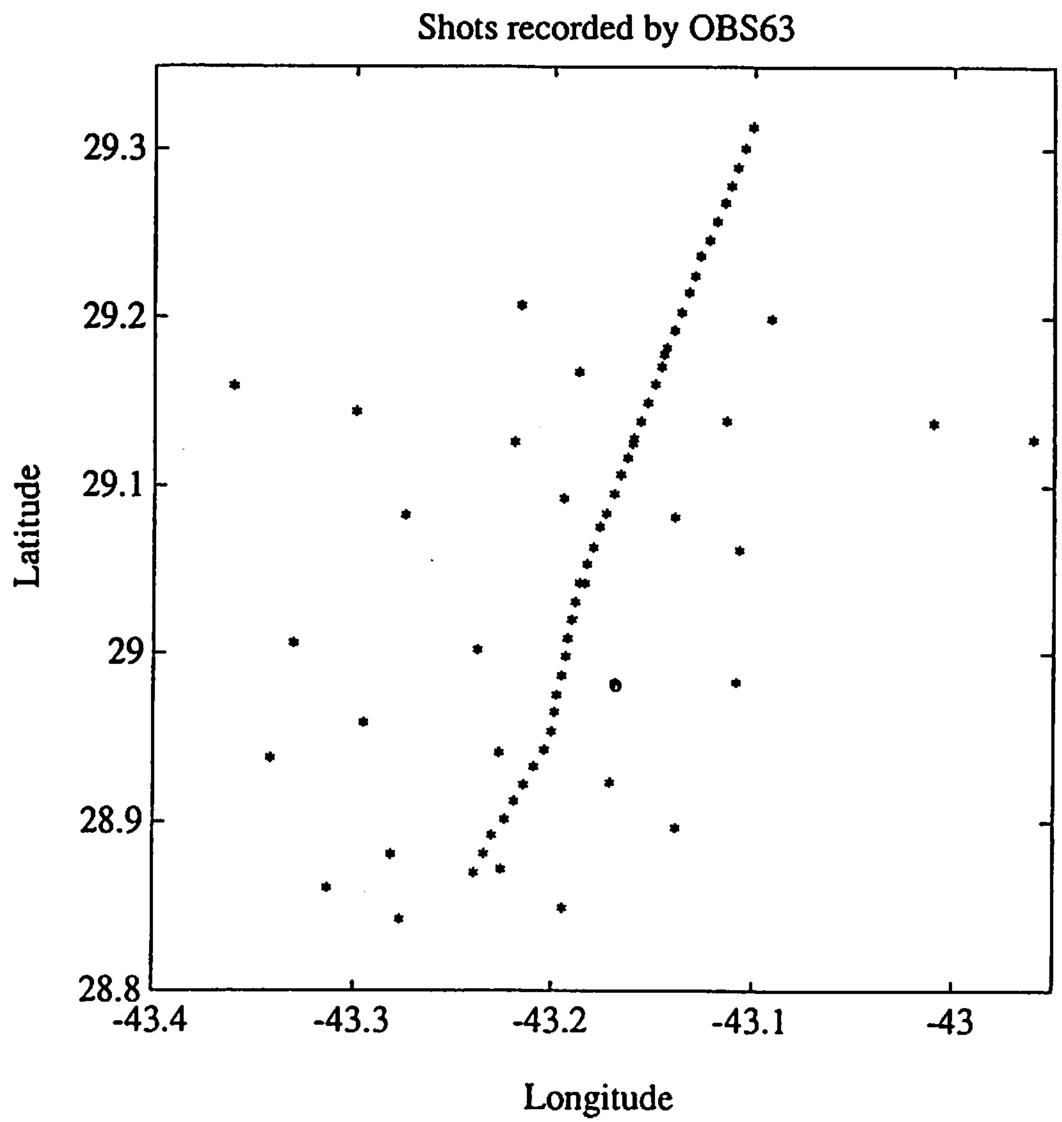


FIGURE A13.2 Locations of the explosive shots (asterisks) recorded by OBS 63 relative to the location of the OBS (open circle).

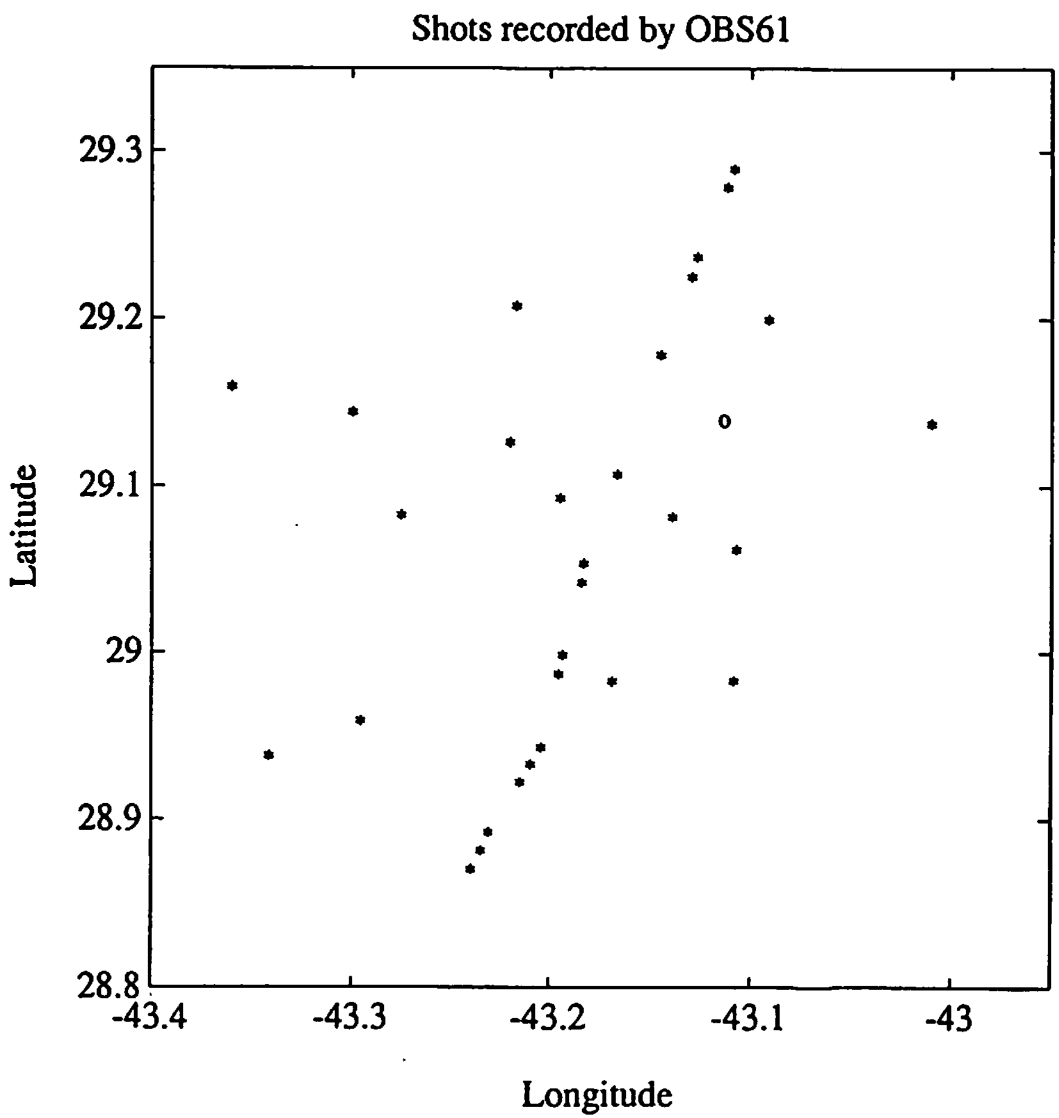


FIGURE A13.3 Locations of the explosive shots (asterisks) recorded by OBS 61 relative to the location of the OBS (open circle).

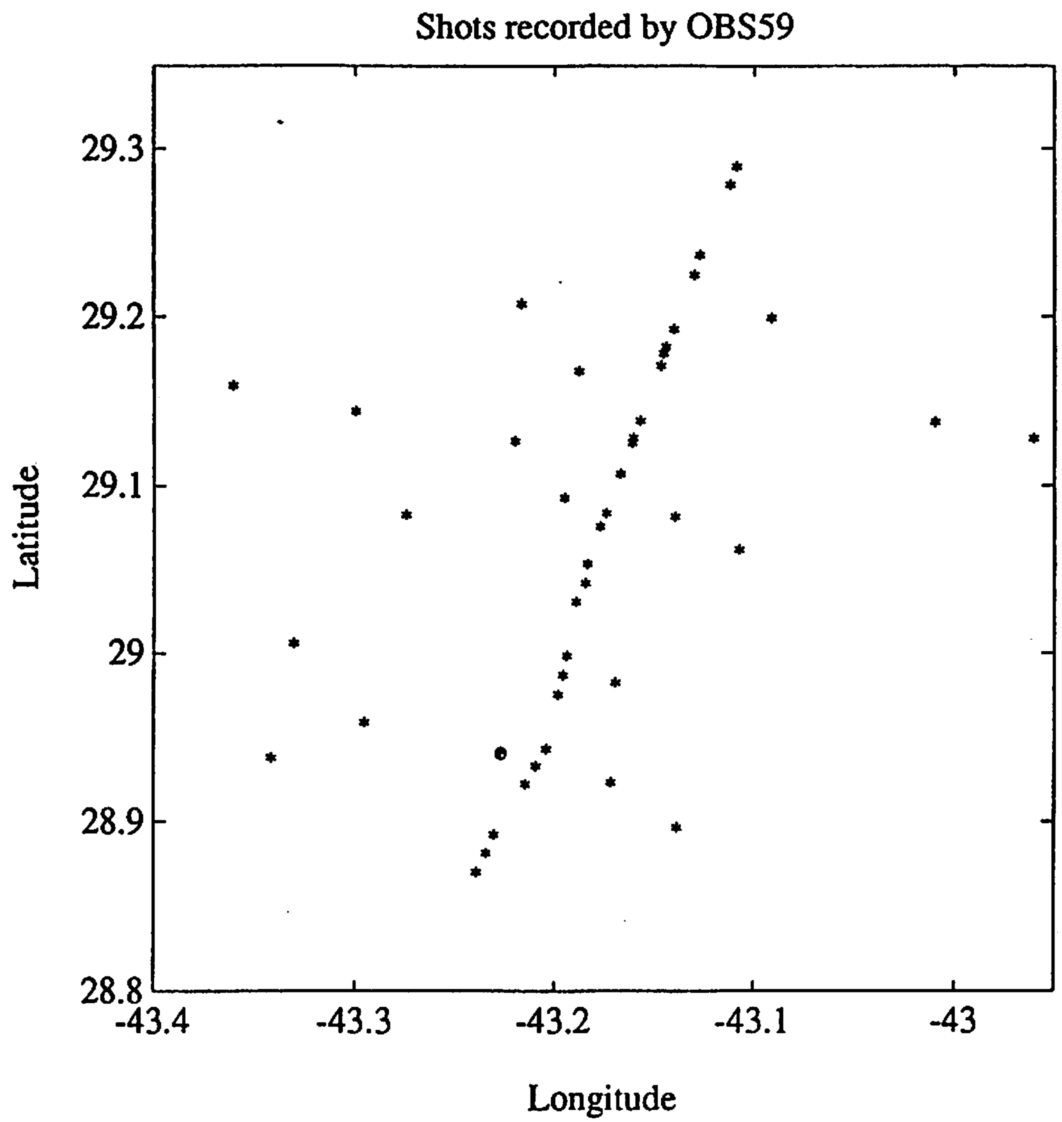


FIGURE A13.4 Locations of the explosive shots (asterisks) recorded by OBS 59 relative to the location of the OBS (open circle).

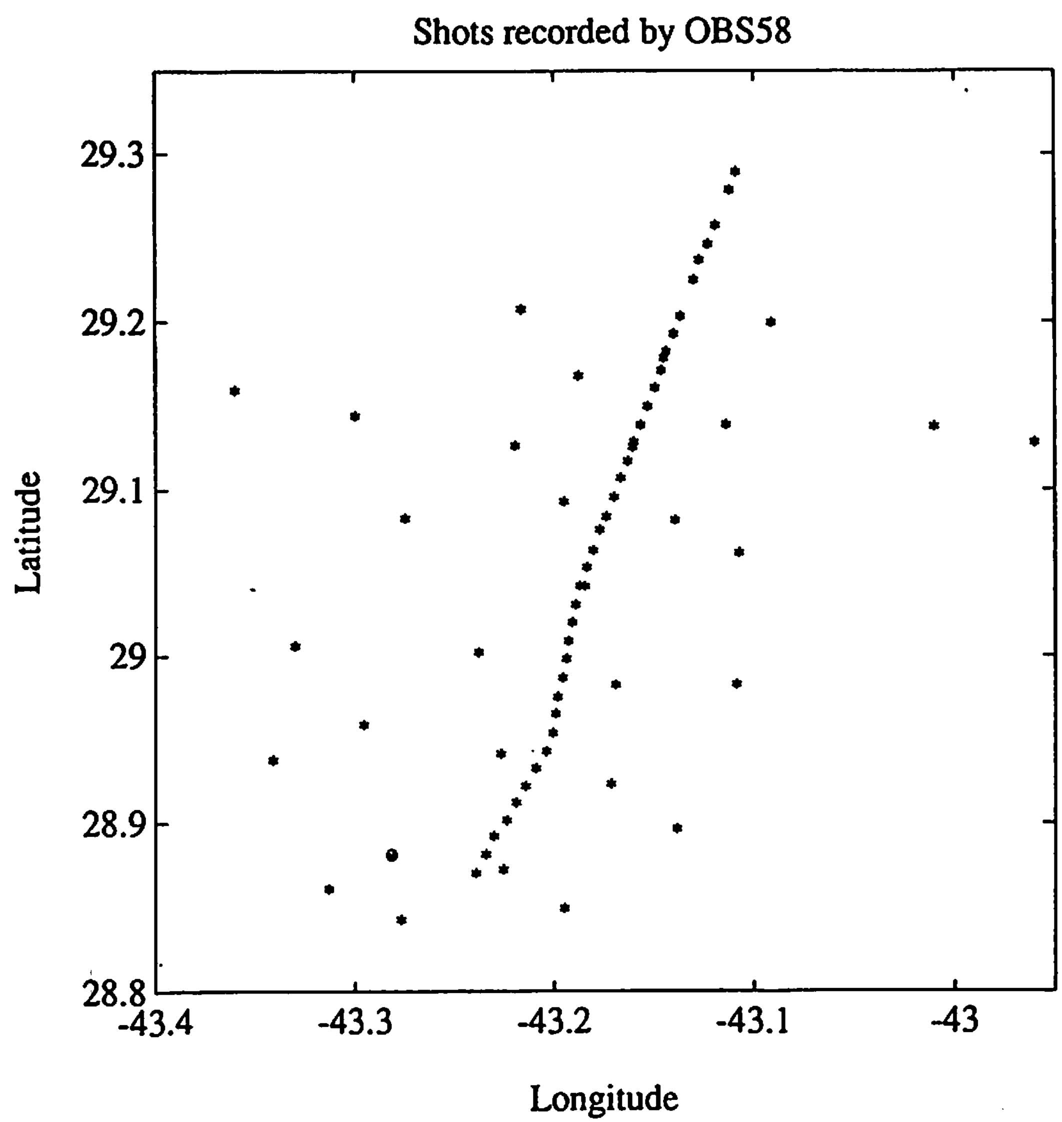


FIGURE A13.5 Locations of the explosive shots (asterisks) recorded by OBS 58 relative to the location of the OBS (open circle).

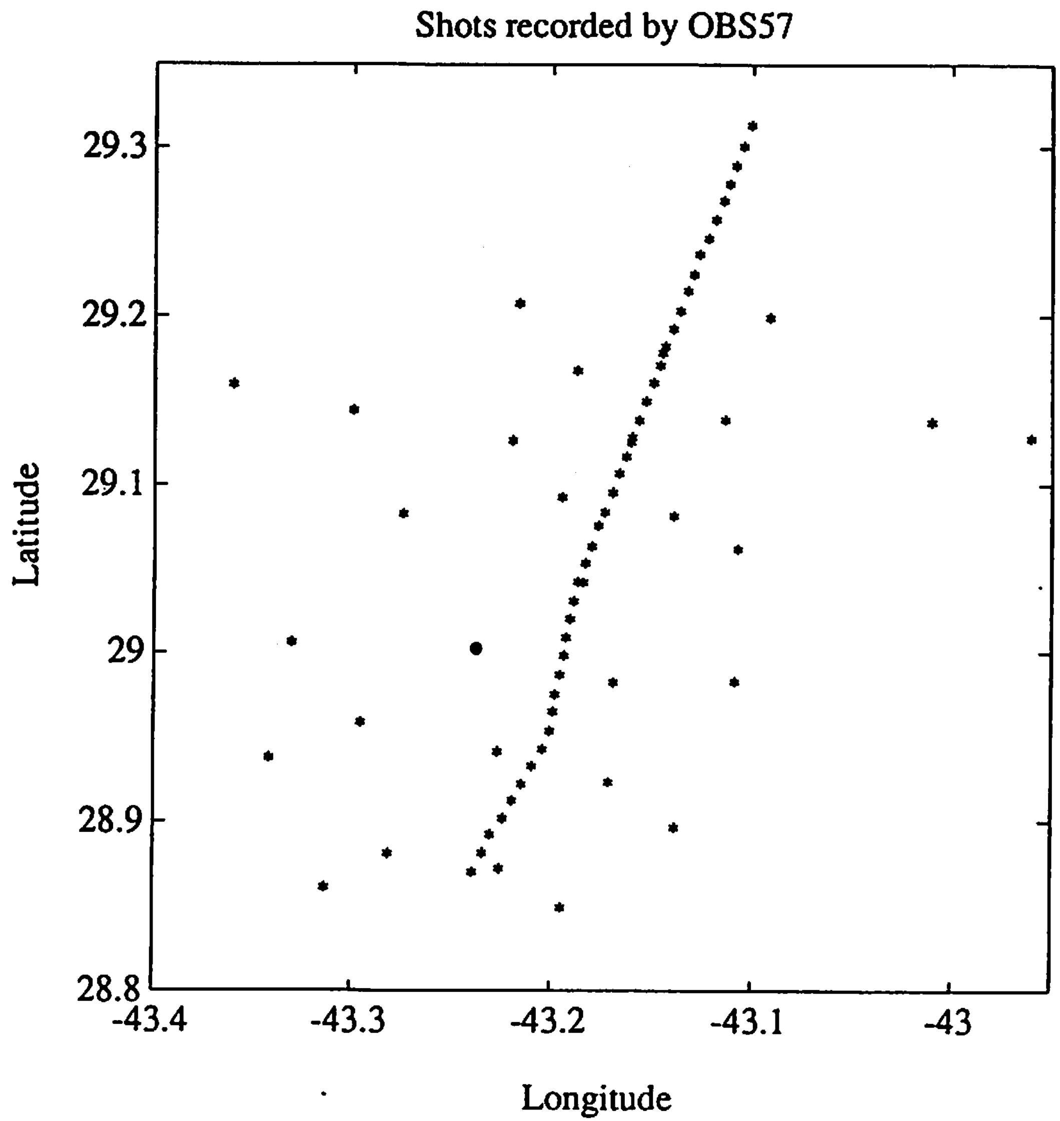


FIGURE A13.6 Locations of the explosive shots (asterisks) recorded by OBS 57 relative to the location of the OBS (open circle).

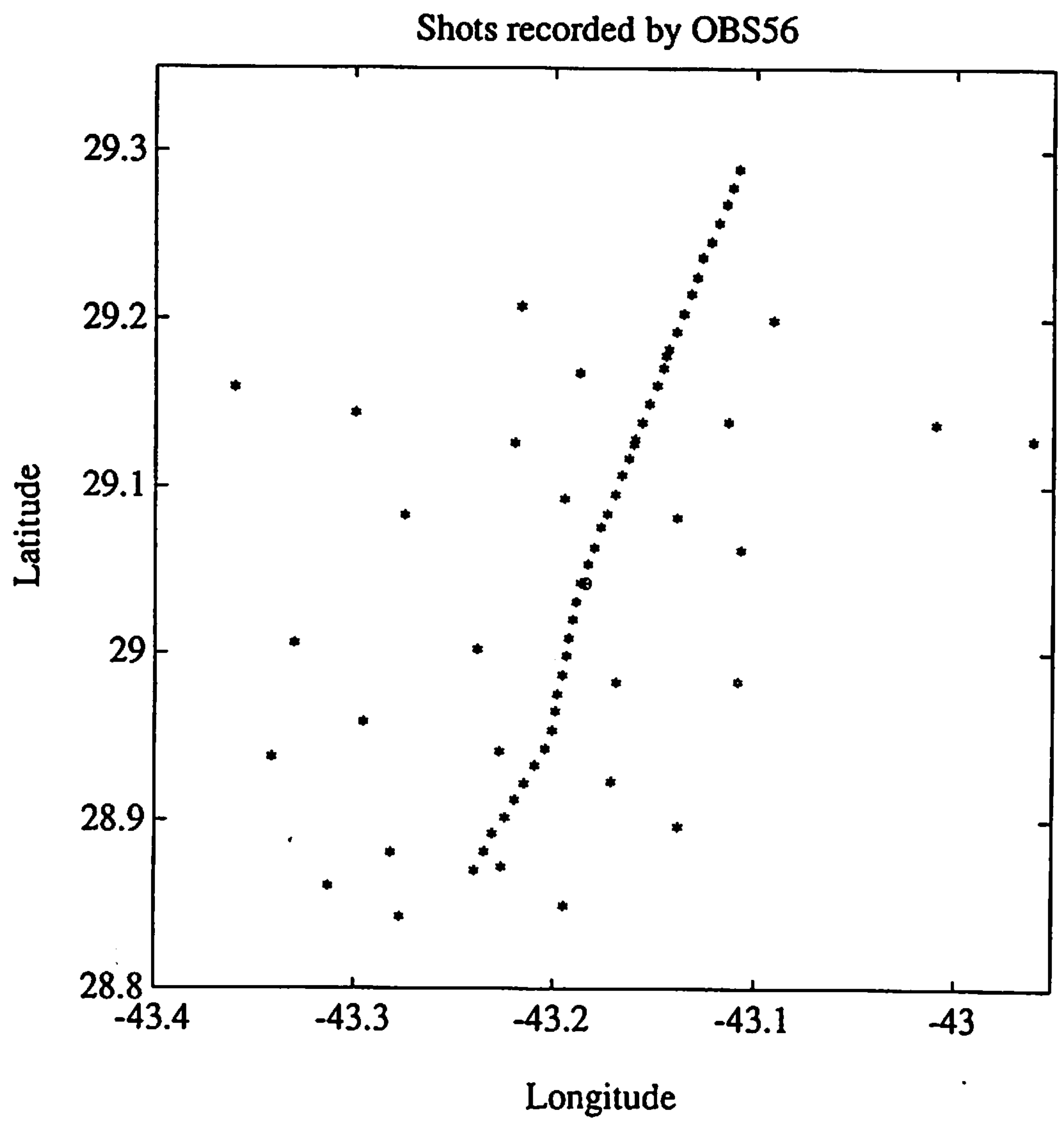


FIGURE A13.7 Locations of the explosive shots (asterisks) recorded by OBS 56 relative to the location of the OBS (open circle).

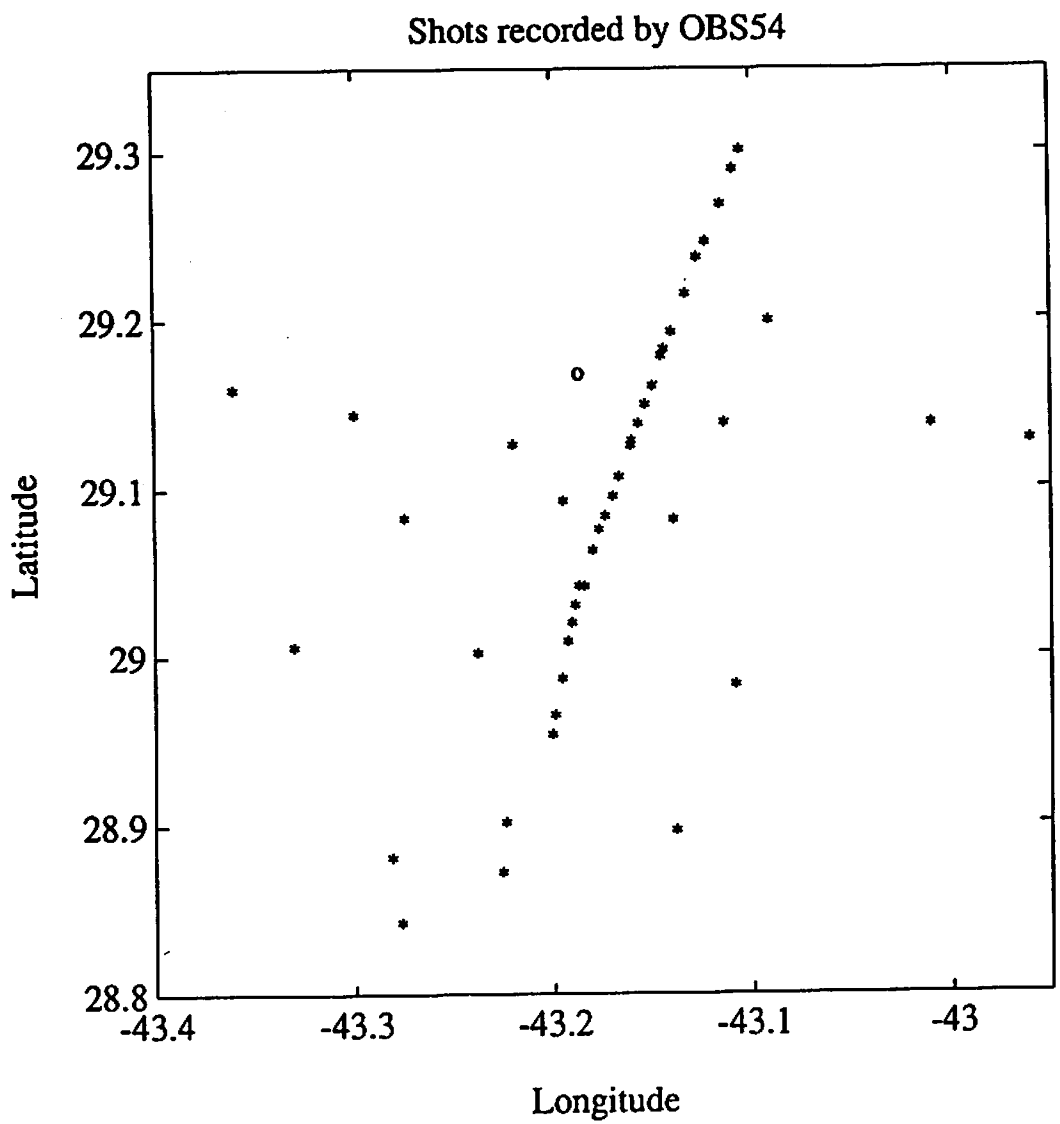


FIGURE A13.8 Locations of the explosive shots (asterisks) recorded by OBS 54 relative to the location of the OBS (open circle).

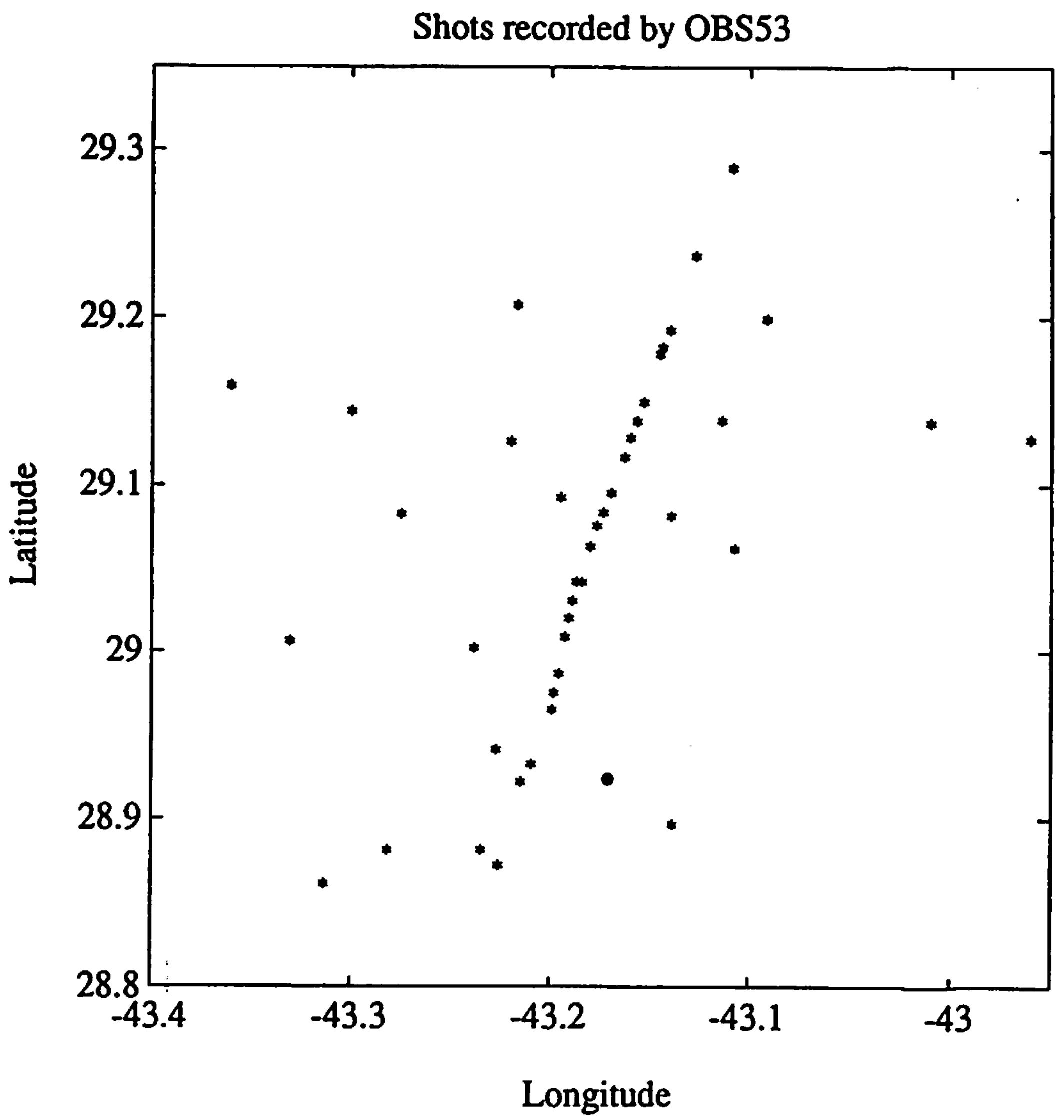


FIGURE A13.9 Locations of the explosive shots (asterisks) recorded by OBS 53 relative to the location of the OBS (open circle).

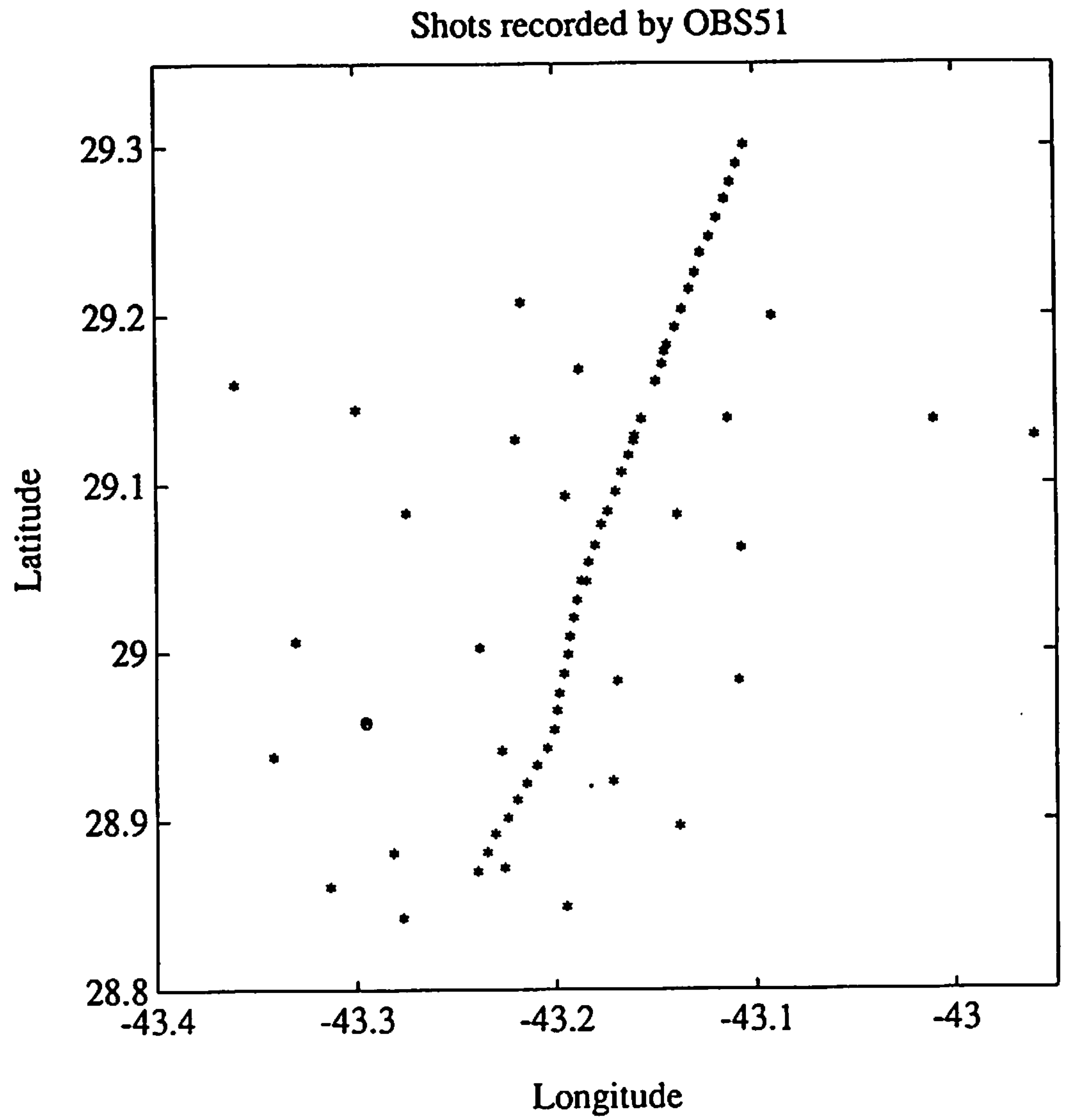


FIGURE A13.10 Locations of the explosive shots (asterisks) recorded by OBS 51 relative to the location of the OBS (open circle).

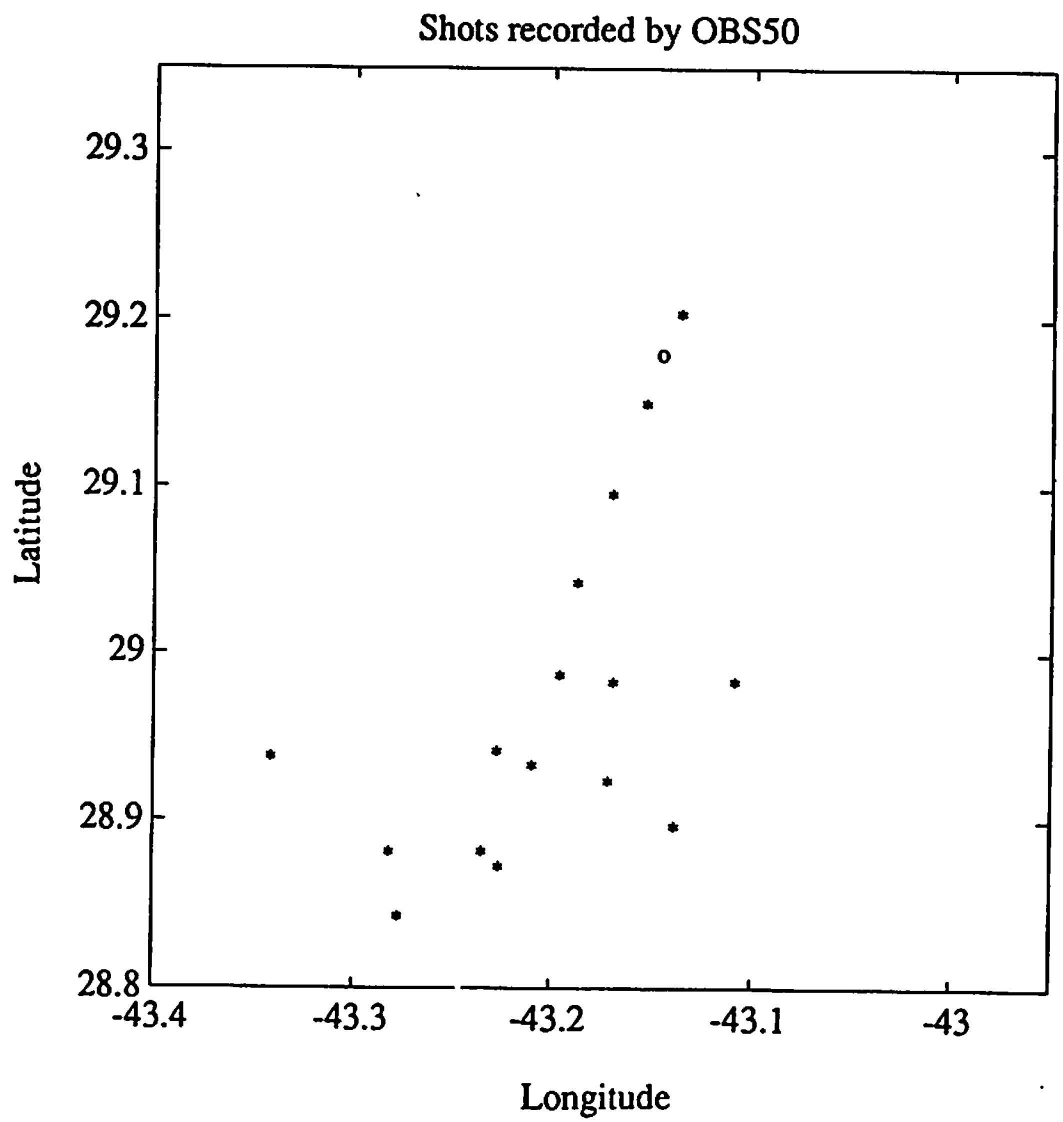


FIGURE A13.11 Locations of the explosive shots (asterisks) recorded by OBS 50 relative to the location of the OBS (open circle).

Appendix 14 FARA 02 Airgun Shooting Tracks

Date	Time(GMT)	Waypoint	Comment
11/2/92 (307)	2100	1	Start, course 250°
	2140	2	c/c 109°
	2204		both guns operational
	2228	3	c/c 192°
	2321	4	c/c 312°
11/3/92 (308)	0045	5	c/c 184°
	0112	6	c/c 135°
	0248	7	c/c 171°
	0315	8	c/c 303°
	0441	9	c/c 194°
	0518	10	c/c 125°
	0608	11	c/c 229°
	0642	12	c/c 017° Start first median valley (mv) line
	0855		c/c 355°
	1039	13	c/c 255° end mv line 1
	1057	14	c/c 173° start mv line 2
	1245	15	c/c 200°
	1538	16	c/c 290° end mv line 2
	1618	17	c/c 024° start mv line 3
	1820	18	c/c 145° end mv line 3
	1902	19	c/c 243°
	1955	20	proposed c/c 160°
	1957:10.924		time of last shot logged, SP35993
	2019		c/c 260° for Bermuda

KEY

Times from Mainlab logbook.

c/c = change course
SOL = Start of Line
EOL = End of Line
SP = Shot Point

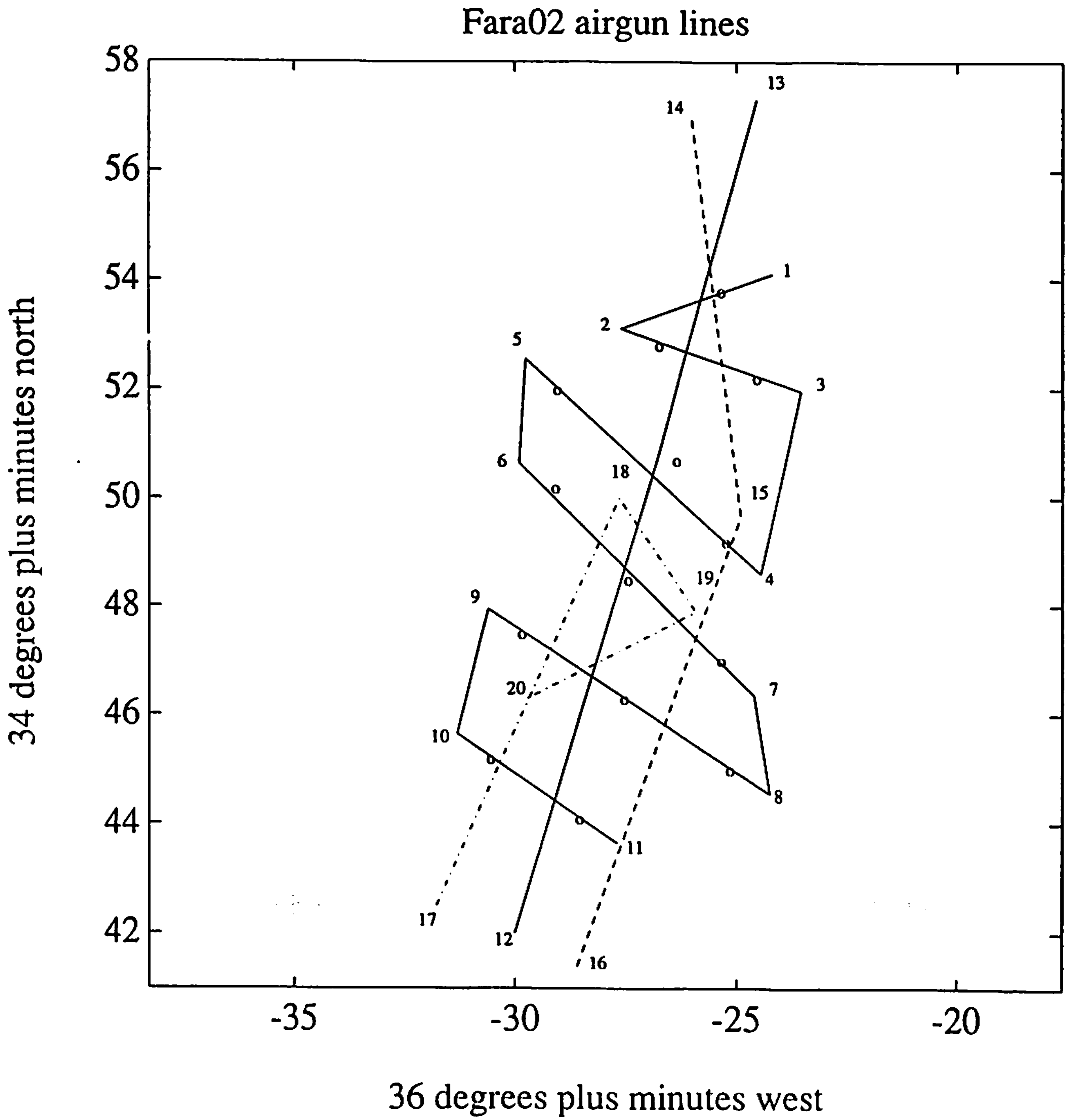


FIGURE A14.1 FARA 02 airgun tracks. Open circles are the OBS. Numbers correspond to waypoints listed on previous page

Appendix 15 Data Handling and Processing

Data Handling on EW9210

Two SUN workstations, indigo and paulina, (both running version 3.5j of MATLAB), an Exabyte cartidge tape drive, and a Maxtor optical disc drive were brought aboard the Ewing for handling the OBS data. The plotting software, GMT was installed on the paulina while at sea. We were also able to gain access to one of the Ewing's SUNs, manta.This third machine proved very useful, since there were often times when four people needed a work station at the same time. Paulina had disk problems after shipping to Barbados. The computer technician on the Ewing, was able to get paulina up and running after the first few days at sea.The gigabyte data disk on indigo died in the fifth week of the cruise and could not be restored.We lost a couple of days worth of work due to this failure and had to depend on paulina for storing large datasets. On the Oceanus cruise and on the Ewing cruise, the SUN computers and associated software have proved essential for data analysis. Due to the possibility of disk failure, future cruises should carry more than one SUN and weekly backups should be made. It was also helpful to have occassional access to the Ewing's computer technician who sorted out various computer problems and automounted indigo and paulina.

BACKUPS OF THE OPTICAL DISK:

Immediately following recovery the OBS's Maxtor optical disk with data from FARA01 was backed up to Exabyte tape using the dd command:

```
dd if=/dev/rsod0a ibs=2048000 obs=2048 of=/dev/rst1
```

Although the input block size for the disk is actually 2048,it was found that the transfer of data from the optical disc was considerably faster if the input block size is increased. With an input block size of 2048, a full disk would take on the order of 12 hours, whereas with the increased input block size the transfer takes about 2 hours. The reason for this difference should be investigated.

On some optical disks, there existed so-called "bad blocks" that produced I/O errors on the SUN and caused the dd software to terminate. This problem was investigated by putting one of these disks back into the instrument, reading a portion of data with "bad blocks" on the IBM compatible PC, and outputting a binary file. When data read in this manner was ftp'd to the SUN, it could be read and reformatted without any trouble. It was then found that the "bad blocks" could also be read on the SUN by using the dd optionconv=noerror, so that the dd program would not halt on error, and setting the input block size to 2048 (note that scrolling should be turned off in the command window and in the console window to prevent filling up the root partition with the information produced by error messages):

```
dd if=/dev/rsod0a bs=2048 conv=noerror of=/dev/rst1
```

Although the "bad blocks" still produced I/O errors, we were able to back up an entire disk without any loss of data and the data within the "bad blocks" appeared to be undamaged. A second problem on the optical disks was found on the FARA02 Test and on the 100 Mb tests, but was not found on the FARA01 data. Empty blocks were found on portions of some optical disks. These empty blocks result in a loss of data and cause termination of the dd program. For example, the first 32 blocks of the FARA02 test were empty, which coincided with the loss of an hour's worth of data at the beginning of the test. The only way to read beyond empty blocks is to reposition the Maxtor past them, using the odt command on the SUN, and then run the dd command. The procedure followed was to try different positions beyond the first empty block, attempt to dd the data, and continue transcribing when a position with full blocks was found.

For example, first make sure the disk is write protected, and login as root and type:

```
odt -t /dev/rsod0a Load
```

Now the optical can be positioned and repositioned to any block on the disk by typing:

```
odt -t /dev/rsod0a setbase block#
```

When finished, type:

```
odt -t /dev/rsod0a Uload
```

For FARA02, it is recommended that the optical disks are write-protected upon removal from the instrument.

REFORMATTING OF EVENT DETECT DATA:

After backing up the optical disks, the next procedure was to create event listings of the data. These listings were created by running the program "obsed" with the single option ef=(name of file for listing). A simultaneous reformatting of the data into day files could also have been run at this point without significant loss of time, but in the interests of simplicity, this step was delayed. The log file for this program, obs.log,was renamed and saved for later investigation. Note that the scrolling should be turned off in the command window when running this program on large datasets to prevent filling the root partition with history information.

The event detect data were reformatted using "obsed" into SEGY-formatted day files, consisting of all the events that commenced on a given Julian day on a given OBS. Four traces are written for each event, correspondingto the data recorded on the four OBS channels. The naming convention for these files is s(acquisition #)d(Julian day #).dat. An ascii file index for the day file was created and named s(acquisition #)d(Julian day #).ef. The day files were tar'd to exabyte for storage and removed from the SUN.The program segy2mat was used to extract an event from a day file and produce a .mat file for input into MATLAB. The SEGY header is compatible with the PASSCAL modified SEGY format. The PASSCAL triggertime is written as the event start time.

Here is an example of reading data from the optical to create day files and output an event listing called obs59.ef:

```
dd if=/dev/rsod0a ibs=2048000 obs=2048 | obsed ff=edsegy ef=obs59.ef
```

One could also use:

```
obsed if=/dev/rsod0a ff=edsegy ef=obs59.ef
```

The first example results in faster execution, since reading data from the optical is faster when the block size is increased.

Here is an example of running segy2mat to look at the fifth event in the day file s17d235.dat segy2mat s17d235.dat -evtnum 5

The matlab file is named s(acq #)d(Julian day, hour, minute, and second of starting time of event).mat.

Missing bytes, which are indicated in the obs.log by missing data headers, were found on several of the disks. However, it was not a pervasive problem and, at most, only a few tens of events per disk were lost.

TIMING CORRECTION OF EVENT DETECT DATA:

The program modhdr was created to modify the SEGY headers of events in the day files, replacing the original time of an event with the true time, as corrected for clock offset and drift. At this point, the instrument number in the header is also changed from the acquisition number to the OBS frame number. There was not time at sea, however, to run this program on the day files. The timing correction for an instrument is calculated using the sum of the Bigtime correction and the SAIL correction at the predeployment and postdeployment Bigtimes, values which are calculated as described in Appendix 6 and are given in the table of Appendix 6.For each event in a SEGY day file, the starting time in the SEGY header is read and converted from Julian day, hour, minute, and second into Bigtime units (seconds since 1970). The predeployment and postdeployment corrections are then used to calculate an event Bigtime correction by linearly interpolating to this event time:

correction = (event Bigtime - predeployment Bigtime) *
(postdeployment correction - predeployment correction) /
(postdeployment Bigtime - predeployment Bigtime) +
(predeployment correction

The calculated correction is then added to the event Bigtime. This new time is converted to Julian day, hour, minute, second, and millisecond and written in the segy header.

Due to an error, the predeployment corrections were not recorded for OBS 53. The Seascan and SAIL offsets were recorded on day 230, a few days before the deployment, but the Bigtime offset was not recorded at this time (see entry in table of Appendix 6).The Bigtime drift during deployment was therefore assumed to be the same as the Seascan drift. A Bigtime correction of -0.014538 was estimated for the time 230 12:56:55 (714056215 in Bigtime units). The SAIL offset was estimated at -0.000823, as taken on day 230 at 15:30:00 (Table 1, Appendix 14, Oceanus 253 Cruise Report).

Here is an example of running modhdr on s17d235.dat.

modhdr if=s17d235.dat

The new version of s17d235.dat should be renamed to avoid confusion (perhaps s(OBS frame #)d235.dat) and backed up to exabyte.

REFORMATTING OF CONTINUOUS DATA:

Continuous data were reformatted into .mat files, for use in MATLAB, using the program obs, by John Collins. The odt facility was used to reposition the optical disc near the end of the disk, where the continuous data was collected. A small amount of continuous data was then reformatted for the purpose of checking instrument performance in this phase of recording. These MATLAB files were not backed up to exabyte.

Here is an example of running obs to output 10 matlab files:

obs if=/dev/rsod0a ff=mat rr=10

DATA ANALYSIS:

The data onboard EW9210 were read into MATLAB for plotting and analysis. On both EW9210 and Oceanus 253, we found MATLAB an important tool. In addition to the simple plotting of seismograms, MATLAB was also useful for making picks on seismograms, calculating the STA/LTA estimates from continuous data, filtering seismograms to estimate the effects of a modified preamp, calculating event statistics, and obtaining lists of events recorded on several instruments within a given time window.

The program reksek is used for making record sections. The program ttpik is useful for plotting out individual seismograms and small portions of individual seismograms. The program qqpick3 is another program for plotting record sections or individual seismograms,and making picks. The program inkjet can be used to plot one channel of several seismograms on a single page.

SEGY HEADERS OF EVENT DAY FILES

For each event, four traces are written to a SEGY-formatted day file, corresponding to the data recorded on the four channels of theOBS. This day file contains all the events that occured on a given Julian day on a given OBS. Each trace is written in SEGY format and preceded by a SEGY data header.

A SEGY format compatible with the PASSCAL modified SEGY format was used. The modification comes from the fact that PASSCALuses some of the unspecified header words to store information pertinent to the PASSCAL data. The values assigned in the 240-byte header is as given below. Included after this description is an example of the C language structure used to describe the entire data header.

Byte #	Description
1 - 4	Trace sequence number within event file
5 - 8	Trace sequence number within reel (same as above)
9 - 12	Event number in event file
13 - 16	Channel number
29 - 30	Trace identification code = 1 for seismic data
69 - 70	Elevation constant = 1
115 - 116	Number of samples in this trace
117 - 118	Sample interval in microsecs for this trace (note if equal 1 see bytes 201 - 204)
119 - 120	Fixed gain flag = 1
121 - 122	Gain of amplifier (set to 1 since OBS data scaled up to the maximum preamplifier and agc)
157 - 158	Year data recorded (time recorded is the start time of event)
159 - 160	Day of year
161 - 162	Hour of day (24 hour clock)

163 - 164 Minute of hour
165 - 166 Second of minute
167 - 168 Time basis code: 1=local 2=GMT 3=other (FARA used 3, since UTC)

201 - 204 Sample interval in microsecs as 32 bit integer
(read if number in bytes 117-118 is 1)
205 - 206 Data format flag: 0=16 bit integer 1=32 bit integer
(data format flag for FARA is 1)
207 - 208 Milliseconds of second for first sample
(milliseconds of start time of event)
209 - 210 Trigger time year
(trigger times are all set to start time of event)
211 - 212 Trigger time julian day
213 - 214 Trigger time hour
215 - 216 Trigger time minutes
217 - 218 Trigger time seconds
219 - 220 Trigger time milliseconds
221 - 224 Scale factor (IEEE 32 bit float) (scale factor = 1 for FARA)
225 - 226 Instrument number

Structure for trace header variables; 240 bytes

```
struct segy_trace_hdr {
   long   trace_seq_line;       /* sequence number within data stream */
   long   trace_seq_file;       /* sequence number within file or reel */
   long   event_number;         /* original field record number */
   long   channel_number;       /* trace # within original field record */
   long   energy_source_pt_num; /* used when more than one record occurs at
                        the same effective energy location */
   long   cdp_ensemble_number;  /* CDP ensemble number */
   long   trace_num_ensemble;   /* trace number within ensemble */
   short  trace_id_code;        /* trace identification code:
                        1 = seismic data; 2 = dead; 3 = dummy;
                        4 = time break; 5 = uphole; 6 = sweep;
                        7 = timing; 8 = water break;
                         9 = optional ... */
   short  vert_sum;             /* # of vertically summed traces yielding
                        this trace */
   short  horiz_sum;            /* # of horizontally stacked traces
                        yielding this trace */
   short  data_use;             /* 1 = production; 2 = test */
   long   srce_recvr_range;     /* source to receiver range */
   long   recvr_elev;           /* receiver elevation; all values above
                        sea level are positive (+ve) */
   long   surface_elev_srce;    /* surface elevation at source */
   long   srce_depth;           /* source depth below surface; (a +ve #) */
   long   datum_elev_recvr;     /* datum elevation at receiver */
   long   datum_elev_srce;      /* datum elevation at source */
   long   srce_waterdepth;      /* water depth at source */
   long   recvr_waterdepth;     /* water depth at receiver */
   short  elev_depth_scale;     /* scaler to be applied to all elevations
```

```
                    and depths specified in bytes 41-68 to
                    give the real value. If +ve, scaler is
                    used as a multiplier; if -ve, scaler is
                    used as a divisor */
short  coord_scale;         /* as above but for bytes 73-88 */
long   srce_xcoord;         /* if units are in seconds of arc, the
                    X values represent longitude and the
                    Y values represent latitude. A +ve
                    value designates the # of seconds west
                    of Greenwich or north of the equator. */
long   srce_ycoord;         /* as above */
long   recvr_xcoord;        /* as above */
long   recvr_ycoord;        /* as above */
short  coord_units;         /* 1 = length (meters or feet);
                    2 = seconds of arc */
short  weathering_velocity;
short  subweathering_velocity;
short  srce_uphole_time;    /* uphole time at source */
short  recvr_uphole_time;   /* uphole time at receiver */
short  srce_static_corr;    /* source static correction */
short  recvr_static_corr;   /* receiver static correction */
short  total_static_applied; /* zero if no static applied */
short  lag_time_a;          /* time in ms. between end of 240 byte
                    trace hdr. and time break. +ve if break
                    occurs after end of hdr, -ve if before
                    end of hdr. Time break is the initiation
                    pulse which may be recorded on an
                    auxiliary trace.   */
short  lag_time_b;          /* time in ms. between time break and
                    initiation time of energy source. May
                    be +ve or -ve. */
short  delay_time;          /* time in ms. between initiation time
                    of energy source and time when data
                    recording begins. */
short  mute_time_start;
short  mute_time_end;
short  number_of_samples_2b; /* # of samples in this trace. If value
                    equals 1, then read variable
                    "number_of_samples_4b" */
short  sample_interval_2b;  /* sample interval in microseconds.
                    If value equals 1, then read variable
                    "sample_interval_4b" */
short  gain_type;           /* 1=fixed; 2=binary; 3=floating point;
                    4=other (optional use) */
short  gain_const;          /* amplifier gain */
short  initial_gain;        /* in dB */
short  correlation_trace;   /* trace correlation: 1=no; 2=yes */
short  sweep_freq_start;    /* sweep frequency at start */
short  sweep_freq_end;      /* sweep frequency at end */
short  sweep_length;        /* sweep length in ms */
short  sweep_type;          /* 1=linear; 2=parabolic; 3=exp; 4=other */
short  sweep_taper_len_start; /* sweep trace taper length (ms) at start */
short  sweep_taper_len_end;  /* sweep trace taper length (ms) at en   d */
short  taper_type;          /* 1=linear; 2=cos**2; 3=other */
```

```
short  anti_alias_freq;
short  anti_alias_slope;
short  notch_freq;
short  notch_freq_slope;
short  low_cut_freq;
short  high_cut_freq;
short  low_cut_slope;
short  high_cut_slope;
short  year;              /* year data recorded */
short  day;               /* day of year data recorded */
short  hour;              /* hour of day data recorded */
short  minute;            /* minute of hour data recorded */
short  second;            /* seconds of minute data recorded */
short  time_basis_code;       /* 1=local; 2=GMT; 3=other */
short  trace_weight;         /* 2**-n volts for lsb; n = 0,1,2,... */
short  recvr_num_roll_switch_one; /* geophone group # of roll switch
                    position one */
short  recvr_num_first_trace;  /* geophone group # of first trace
                  within original field recording */
short  recvr_num_last_trace;  /* geophone group # of last trace
                  within original field recording */
short  gap_size;            /* total # of groups dropped */
short  taper_overtravel;      /* overtravel associated with taper at
                  beginning or end of line:
                  1=down (or behind); 2=up (or ahead) */
short  trace_spare1[TRACE_SPARE1_SIZE/sizeof(short)]; /*bytes 181 - 200 */
long   sample_interval_4b;    /* sample interval in microseconds */
short  data_format_flag;      /* 0=16 bit integer; 1=32 bit integer */
short  first_sample_ms;       /* millisecond of second of first sample */
short  trig_year;           /* trigger time year */
short  trig_d    ay;          /* trigger time day of year */
short  trig_hour;           /* trigger time hour of day */
short  trig_minute;          /* trigger time minute of hour */
short  trig_second;          /* trigger time second of minute */
short  trig_millisecond;       /* trigger time millisecond of second */
float  data_scale;           /* multiplicative scale factor (IEEE 32 bit
                  bit float); (true amplitude = data value
                  * data_scale / gain constant ) */
short  instrument_number;      /* instrument serial number */
short  not_to_be_used;
long   number_of_samples_4b;  /* number of samples in this trace (4
                  byte integer) */
short  trace_spare2[TRACE_SPARE2_SIZE/sizeof(short)]; /*bytes 233 - 240 */
```

Plans for a Matlab Microearthquake Data Reduction System

Introduction

MEQ is a toolbox of Matlab compatible functions and scripts that aid in the reduction and analysis of marine microearthquake data sets. Because the routines within MEQ are written by the analyst, it is expected that the toolbox contents will continually evolve. In an effort to develop some consistency regarding the programming style and usage of m-files within the toolbox, this document outlines the ground rules for the MEQ toolbox.

1.0 Directory Structure

Following is a description of the directory structure for the MEQ system, including specifications for the types of files to be found in the main directory and its sub-directories, and the naming convention for sub-directories.

1.1 MEQ: The top directory for software related to the MEQ system. Within this directory can be found the basic M-files and supporting sub-directories that comprise a Matlab-based toolbox. A suggested location for this directory is off a 'data' partition, allowing sufficient disk space for the sub-directories of MEQ to contain binary MAT-files (e.g., /data/fara1/MEQ).

Access to the MEQ toolbox via Matlab requires the following line to be included in the user's .cshrc file:

setenv MATLABPATH /data/fara1/MEQ

1.2 Primary M-files within MEQ: Only so-called *primary* m-files and sub-directories should be located within MEQ. A primary m-file is a function or script file that performs an often used task, for example conversion of header information, plotting of seismograms, or picking of phase data. The goal is to keep the contents of the MEQ toolbox to a manageable minimum.

1.3 Secondary M-files within MEQ-sub-directories: Because many *primary* m-files will require supporting functions, all secondary M-files will be stored in sub-directories. A secondary m-file is one that is called only by a primary m-file which is located in the toolbox directory (../MEQ). For example, a function for picking seismograms called qqpick.m may repeatedly use a set of commands that plot a line indicating a pick. For ease of programming, the commands which draw the pick may best be stored as a function in a sub-directory. Such supporting or secondary m-files should be stored in a directory named as follows:

MEQ/misc_qqpick

Using the naming convention [misc_*function-name*] will help identify all sub-directories that contain secondary m-files.

1.4 Binary and Flat-ASCII Mat-files: Data files required by m-files of the MEQ toolbox are stored in the sub-directory:

MEQ/matfiles

Mat-files that may be stored in this sub-directory should be static, meaning that their contents are unchangeable. Examples include relocated station locations, but not microearthquake source parameters. It is expected that Mat-files found in this directory are used by M-files within MEQ.

1.5 Future Sub-directories: All sub-directories related to the MEQ system must reside beneath the directory MEQ. This includes directories containing secondary functions, C and Fortran routines called by Mex-files, and any static data required by scripts/functions within the MEQ sytem.

2.0 Style Guidelines for M-files

Because the software within MEQ will be written by several individuals and because our needs will evolve with time, it is vital that a standard programming style be adopted for all M-files that become part of the MEQ toolbox. Following are several notes regarding the style:

- All functions and scripts should have a concise description of the purpose of the routine at the top (the comment block). This permits use of the help facility within Matlab.
- The first comment line at the top of a function should repeat the topmost line, thereby showing the correct calling procedure.
- The third line should show the function name in caps, and indented to the right are the comments describing the function's or script's purpose.
- Also within the comment block should be a description of the input and output variables, including their expected dimensions, if appropriate.
- If there are functions or scripts that are closely related to the one being described, include a "See also: " line.
- Last within the comment block is the creation date, programmer name, and summary of modifications.

Below is an M-file that conforms to the standard :

```
function [ dlong ] = jul2long ( ydhms )
%function [ dlong ] = jul2long ( ydhms )
%
%JUL2LONG:      Converts YDHMS time in Julian days to long time.
%               The century is not used, so long format is 92365606012345
%
%               Input:  Matrix of YDHMS times      (n x 5)
%               Output: Vector of longtimes        (n x 1)
%
%               See also: LONG2JUL
%
%               Andy Barclay, Oct-25-92
%
dlong = 10^3 .* ydhms(:,5) + 10^5 .* ydhms(:,4) + 10^7 .* ydhms(:,3);
```

```
dlong = dlong + 10^9 .* ydhms(:,2) + 10^12 .* rem(ydhms(:,1), 100);
```

In addition to the style guidelines above there are normal programming procedures that when followed will help make MEQ easily understandable to future users:

- if, for, and while loops should be indented
- The length of M-files should be kept to a minimum. Use functions whenever possible.
- Include comment statements.
- Write code that can be vectorized.
- Avoid loops, which cause Matlab to run slowly.

3.0 Protected Variable Names

It is anticipated that certain variable names will be used frequently. In the case of functions, this poses no problems. However, if M-file scripts do become a part of MEQ, then there is a potential for duplicating variable names, and causing havoc. Assuming that some scripts will be necessary, we need a repository for protected variable names. Within MEQ can be found a function called *protected.m* that keeps a list of variable names that are protected. The structure of the this routine is simply one large comment block that lists the variable name and its description. For example:

```
function protected
%
%PROTECTED:        Contains an alphabetical list of protected variable names.
%
%      ydhms              An n x 5 matix of Julian day times.
%
```

4.0 Software Czar

Software contributed to the MEQ system will originate from different institutions, making it necessary to establish a repository. For the near future, all files deemed suitable for the MEQ system should be e-mailed to Andrew Barclay (andrew@mazama.uoregon.edu) who will be the Software Czar for the time being.

So that all software is easily accesible a directory in pub on Mazama will be set up, as well as an anonymous ftp account.

5.0 Software Outline

Following is a list of the contents of the primary data files which store seismograms, picks, and source parameters. Several of these file types will be binary files that are not in a mat-file format, requiring mex-file capabilities to input the data to MEQ.

5.1 File structure of Earthquakes, Shots, and Arrival Time Picks

5.1.1 Design Criteria

- Accesible via Matlab
- Random access
- Attempt to minimize number of files within a directory
- Easily updated
- Ease of addressing

5.1.2 Seismograms (*Earthquake Day Files: EQDF*)

- SEGY format
- Random access from Matlab via Mex-files, SAC, etc.
- Record order is not chronological
- Update new records by appending to EOF
- 256 bytes per header
- 40 s of data; 4 channels

5.1.3 Pick Files (*Pick Day Files: PDF*)

- Stores arrival time and phase descriptions (e.g., P, S, σ, polarity, chan.)
- Random Access
- Record order is not chronological
- Addressing exactly same as EQDF
- 256 bytes per header
- Data vector is a set of mini-pick-headers that includes (Cecily is working on the specific format of these files):
  Estimated event time
  Arrival time pick
  Arrival time uncertainty
  Phase type
  Phase polarity
  Channel of Pick
- Each pick is tagged by the estimated origin time, allowing multiple events per file, and thus multiple picks of P/S waves per file.

5.1.4 Addressing of EQDF and PDF

- Chronological list of First Sample Times (FST's) that points to record number within random access file.
- Identical pointer file for both EQDF and PDF
- Flat ASCII file; Matlab compatible

5.2 Master Event File (MEF)

- Purpose of file is to point from an estimated event time (EET) to the subset of stations that recorded the event, including the FST of the associated seismogram. For example, one line of this file looks like:

  EET STA EQDF-FST STA EQDF-FST STA EQDF-FST

- Given such a list, all sesimograms and picks can be called up for a specfic EET.
- Note that picks are tagged by the EET.
- The Event Time is not the Origin Time (OT). OT is calculated from the data after all picks have been made. Because picks common to an event must be grouped prior to locating the event, an estimate of the event time (EET) must be used as a tag within the MEF and the PDF.
- One estimate of EET could be the earliest FST.

5.3 Source Parameter File (SPF)

5.3.1 File structure

- ASCII flat file, or Mat binary file
- Must be easily read by Matlab as a matix of values, thus allowing sorting capabilities.

5.3.2 Information stored:

- Hypocentral parameters (lat, lon, depth, ot)
- Hypocentral uncertainties
- # of P waves used
- # of S waves used
- Focal mechanism solution (strike, dip, rake)
- P wave moment
- S wave moment

6.0 Summary of Immediate Software Needs

Several algorithms that will be required in the immediate future are listed below. In each case the suggested input and output are listed, and the programming language. The purpose of this initial list is to help guide programmers towards the immediate needs of the group.

6.1 Data Processing Routines

6.1.1 Group common triggers

Input: EDF
Output: MEF (n x (1+2*nsta) matrix)
Lang.: Matlab
Name:
Status:

6.1.2 Generation of EQDF

Input: MEF
Output: EQDF
Lang.: C
Name:
Status:

6.1.3 Generation of preliminary PDF

Input: MEF
Output: PDF
Lang.: C
Name:
Status:

6.2 Analysis Routines

6.2.1 Picking of phase data

Input: MEF and user-supplied information
Output: Picks into PDF
Suggested outline:

- User selects event from list (graphical or alphanumeric)
- Seismograms are input from EQDF via MEX-file
- Seismograms are displayed, including existing picks.

<u>Display</u>:

All seismograms (nsta * 4)
Seismograms from 1 channel, all stations

Seismograms from 4 channels, one station
Single Channel

- Picks are made visually

  Display:

  Show pick location
  Allow input of uncertainty and description

- PDF is updated via MEX-file

Note: Each bullet is a function.
Name:
Status:

6.2.2 Editing of MEF

Input: MEF
Output: Updated MEF

Note: Purpose is to tag those events within MEF that are not to be included in the analysis. For example, a distant event may trigger all the instruments, and thus make it into the EQDF, but the user may decide that it is not worthy of analysis. Two options: 1) delete it from the list. 2) Tag it. For example, change the Longtime from a positive to a negative number. This way, the event can be reconsidered at a later time.

Appendix 16 Clocks

Time measurements for FARA 02 were made using a Seascan SAIL clock running on a rubidium oscillator. The SAIL clock was checked daily against a Trak 8810 G.P.S. clock for drift. The Trak sends a pulse once per second, its positive going edge is synchronized with the one second mark accurate to +/-one microsecond. The SAIL clock receives the pulse at its trigger input and is able to record the exact time of the pulse. (see fig. A16.3)

A log was kept of G.P.S. vs. SAIL clock times. The offsets of the measured times were recorded as corrections. (G.P.S. - SAIL) The correction offsets were entered into a spread sheet and plotted. (see figs. A16.1 & A16.2)

The stability of the rubidium oscillator was calculated from the plots and was found to be one part in $1.7*10^9$

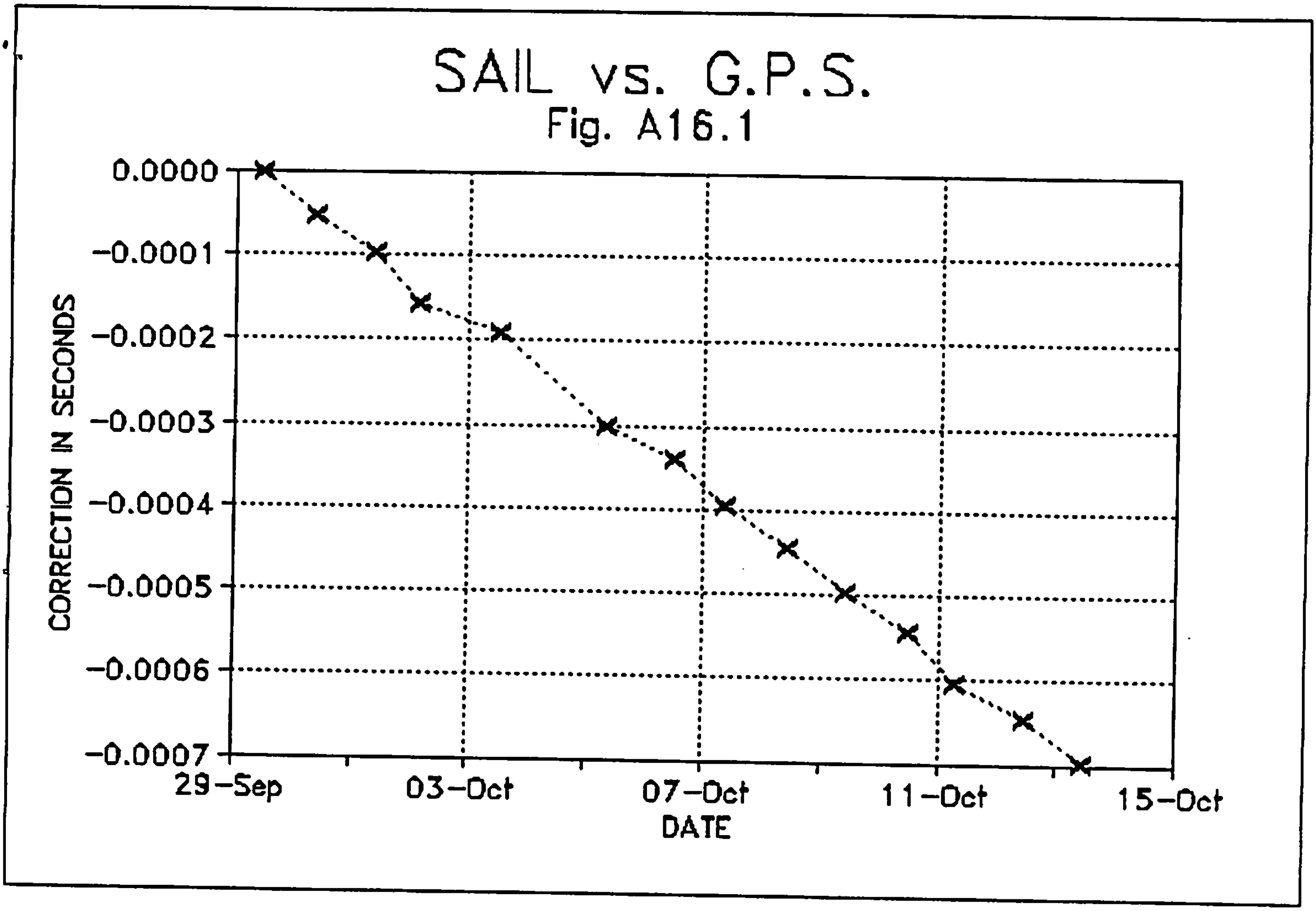


FIGURE A16.1 Plot of offset in seconds versus date for the SAIL Master clock compared with GPS time for the interval 29th September to 15th October.

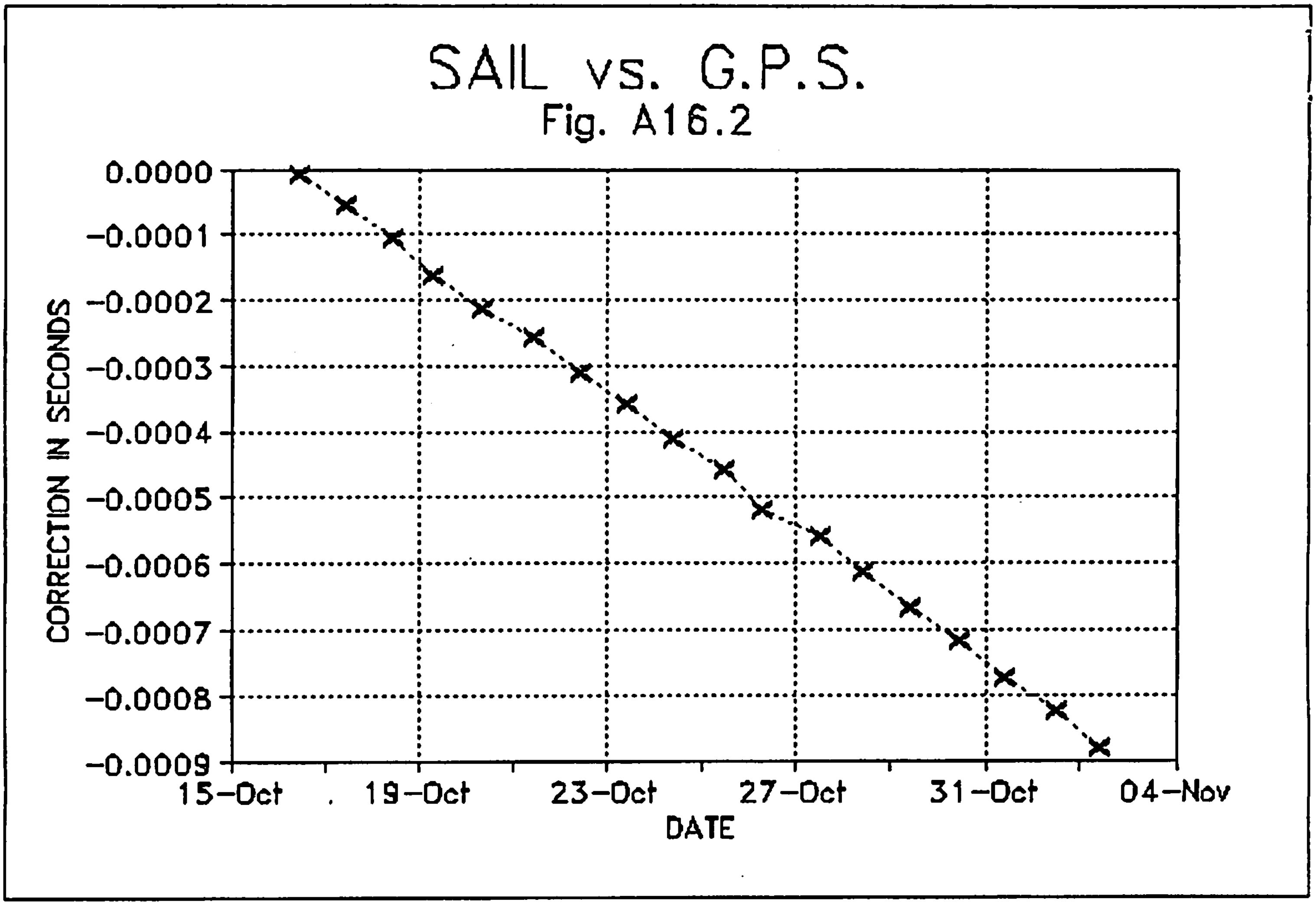


FIGURE A16.2 Plot of offset in seconds versus date for the SAIL Master clock compared with GPS time for the interval 15th October to 4th November..

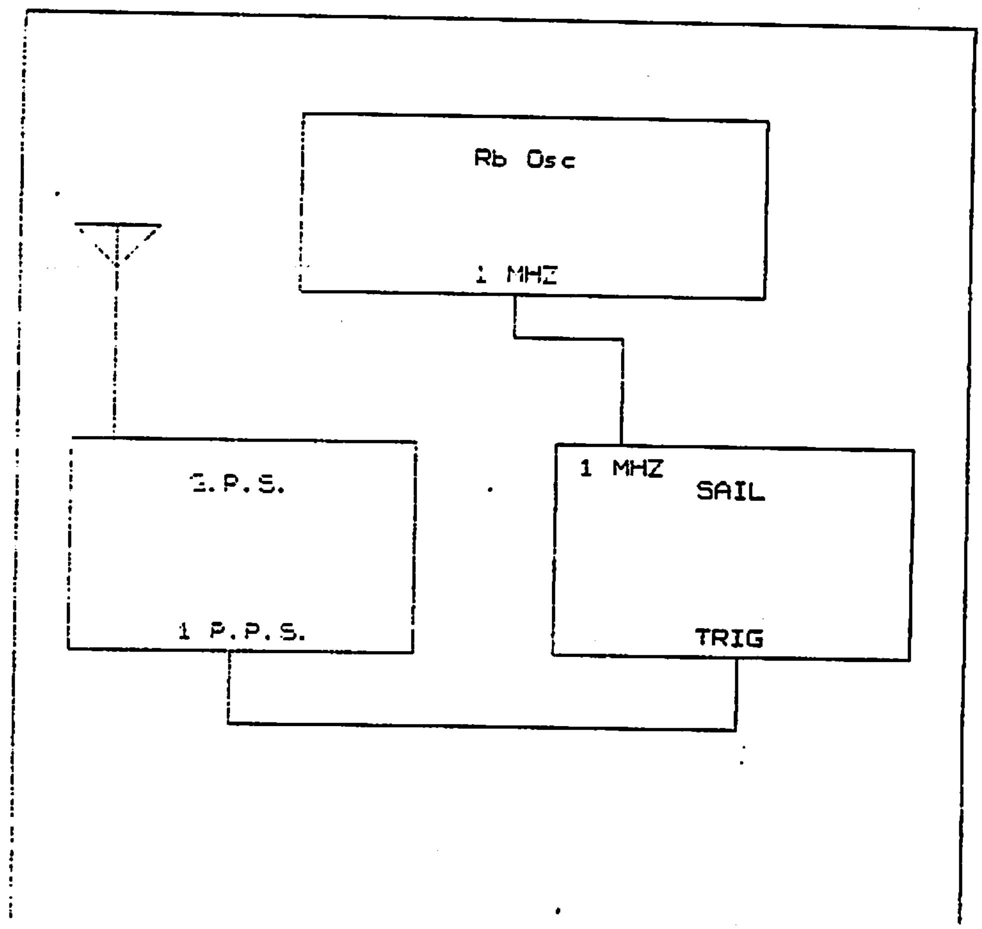


FIGURE A16.3 Block diagram of simple set-up used to compare the Sail and GPS clocks

Appendix 17 EG&G Acoustics System

Mod. 8242 Transponding Releases

During recovery operations, all of the 8242s were given complete acoustic tests. All of them transponded accurately, and responded correctly to commands, with one exception; unit S/N 14738 did not respond with the proper timed ping after release. Even though the OBS lifted off bottom, clearly indicating that the anchor had been dropped, the transponder sent a 2 second timed ping. Likely cause of this problem was a stuck switch. The unit later worked properly when commanded on deck.

Although the transponders of OBS #55 have not been recovered, there is no reason to suspect that the OBS's failure to lift off bottom is related to release failure. Both units on the instrument (S/Ns 13652 & 14156) transponded properly and both sent the 1 second "confirmed release" timed ping when given the release command.

Two days before scheduled redeployment, all of the units were given complete air acoustic tests, and all tested OK.

Just before the OBSs were redeployed, all of the 8242s were again given acoustic tests, again in air, and without the release command, since anchors had been attached, and rerigging was difficult. Some problems were encountered, probably because of noisy conditions on the EWING'S fantail, but eventually all units tested good, again with one exception; S/N 14744 failed
to transmit under any conditions. Attempts were made to enable it with two deck units and two transducers; its location on deck was changed and further attempts made. After failing to get response to range interrogations or disable commands, the release command was sent. The release worked, but transmitted no confirmation pings. At this point it was removed from the frame, and the electronics were drawn from the pressure case. Battery voltages were checked, boards removed and examined. No cause of failure was found, but it was noted that circuits were different from the schematics in the manual. After reassembly, this 8242 worked properly. It was reinstalled on OBS Frame #54 and deployed, but with a low degree of confidence.

Model 8011A Deck Unit

Regrettably, the 8011A deck gear once again failed. It has worked only once--during the FARA 1 deployments. This unit (S/N 14842) is a replacement for a previous 8011A which had a 100% failure rate at sea. Together they represent over three years of bad experiences. The first failed by "locking up" of the keyboard; it would take no commands. The present deck unit fails by losing its ability to receive any signals.

The failure during this cruise was typical of the mode seen from this 8011A. Initially, reception was OK, but as time went by, the receiver seemed to lose gain, requiring lower and lower threshold settings in order to receive any signal. Eventually no signal was received, even with threshold level at 0. Time between reasonable operation and total failure was perhaps 3 hours. System resets, powering down and back up, switching transducers, and removing and reseating cables, PC boards and chips did not cure the problem. Switching deck units to an 8011 immediately brought good signals at threshold settings of 2.5 - 3.1 Volts.

After the initial failure, the 8011A was tested twice. It would not receive during either test.

Appendix 18 Data List

30 OBS receiver logbooks:
- 15 FARA 01 experiment deployments - OBSs 50-64 (14 recoveries)
- 1 FARA 02 test deployment - OBS 54
- 14 FARA 02 experiment deployments - OBSs 50-54, 56-64

1 OBS mainlab logbook

15 Manilla folders of shipboard plots
- 14 FARA 01 folders
- 1 FARA 02 test folder

15 MAXTOR optical disks

1B) FARA 01 OBS 50 REC 32 8/22/92
2A) PreFARA Cold Test ACQ 25 REC 34 7/28/92
B) FARA 01 OBS 51 REC 34 8/19/92
3A) PreFARA Cold Test ACQ 5 REC 38 7/24/92
B) FARA 01 OBS 52 REC 38 8/20/92
4A) PreFARA Cold Test 7/30/92
B) FARA 01 OBS 53 REC 3A 8/20/92
5A) 4 Meg Dump 00 00 00 - 00 07 ff
B) FARA 01 OBS 54 REC 40 8/22/92
6B) FARA 01 OBS 56 REC 36 8/20/92
7A) PreFARA Cold Tests REC 3C ACQ 27 7/24/92
B) FARA 01 OBS 57 REC 3C 8/19/92
8A) FARA 01 Postrecovery Mem Dump 00 00 00 - 00 07 ff
B) FARA 01 OBS 58 REC 28 Full Disk 8/20/92
9A) PreFARA Cold Test REC 26 ACQ 29
FARA 01 Post Recovery Mem Dump 01 67 91 - 01 6f 90
B) FARA 01 OBS 59 REC 26 Full Disk 8/19/92
10A) PreFARA Cold Test 7/30/92
B) FARA 01 OBS 60 REC 2C 8/21/92
11A) PreFARA Cold Test REC 2E ACQ 11 7/28/92
Mem Dump OBS 61 00 bc 82 - 00 c4 81
B) FARA 01 OBS 61 REC 2E 8/19/92
12B) FARA 01 OBS 62 REC 30 8/20/92
13A) PreFARA Cold Test 7/30/92
PostFARA 01 Mem Dump 00 bc 6b - 00 c4 6a
B) FARA 01 OBS 63 REC 42 8/19/92
14B) FARA 01 OBS 64 REC 24 OC253 8/21/92
15B) FARA Leg 2 Predeployment test 10/11/92 OBS 54 REC 40 ACQ 33

10 8mm video cassette tapes of raw data backups

1)	OBS 51	REC 34	10/05/92	
2)	OBS 54	REC 40	10/06/92	
3)	OBS 56	REC 36	10/17/92	
4)	OBS 57	REC 3C	10/06/92	
5)	OBS 58	REC 28	10/05/92	
6)	OBS 59	REC 26	10/05/92	
7)	OBS 61	REC 2E	10/06/92	
8)	OBS 63	REC 42	10/13/92	
9)	OBS 64	REC 24	10/06/92	
10)	OBS 54	REC 40	10/14/92	FARA 02 Test Start LBA 00 08 d3

8 8mm video cassette tapes of uncorrected SEGY day file backups

1a)	OBS 54	ACQ 33	10/08/92
b)	OBS 53	ACQ 17	
c)	OBS 53	ACQ 17	/cont
2a)	OBS 56	ACQ 11	10/18/92
b)	OBS 52	ACQ 59	10/18/92
3a)	OBS 57	ACQ 31	10/11/92
b)	memdumps		10/14/92
c)	memdumps		10/18/92
4a)	OBS 58	ACQ 27	10/08/92
5a)	OBS 59	ACQ 23	10/08/92
6a)	OBS 61	ACQ 1(51)	
b)	OBS 50	ACQ 15	10/20/92
7a)	OBS 63	ACQ 19	10/13/92
b)	OBS 60	ACQ 55	10/22/92
8a)	OBS 64	ACQ 21	10/09/92
b)	OBS 51	ACQ 25	

Other

Copy of selected sections of the Mainlab log

File of navigation data during hydrosweep?, airgun operations Nov 1 - Nov 3
File of shot instants collected during airgun operations Nov 2 - Nov 3

File of gridded hydrosweep data for OBS FARA 02 deployment work area in XYZ GMT format plus the ping editted along track swath data

Magnetics data
Gravity data (data to be mailed following base station corrections in Bermuda)

FARA 01 Recovery and Data Analysis Tally Sheet
FARA 02 OBS Predeployment Preparation Tally Sheet
3-ring Binder of FARA 02 100MB Test Logs and Data Plots
One roll of film of RSLI photos

Appendix 19 Hydrosweep Survey

The science program described in this report was not the primary user of the Hydrosweep system during cruise EW9210 so the comments here will be brief. Our primary requirement was for the collection of approximately 24-48 hours worth of data over the OBS network site for use in carrying out the topographic corrections for the airgun refraction data. A simple survey over the network was planned, the track configuration for which is shown in Figure A19.1. It was intended to merge these data with those collected along the airgun lines (the tracks for which are shown in Figure A14.1) to produce an extraordinarily robust and detailed view of the seafloor topography in this small area. As described elsewhere in this report, it is unfortunate that the weather conditions during the airgun shooting were very poor.

It was feasible for us to work with, and process the Hydrosweep data only because of the complete co-operation of Dr J-C Sempere and his science team. The processing was carried out under the supervision of Dr Anne Briais and Dr Louis Geli. Their assistance in this is gratefully acknowledged.

Two issues are worthy of note. We were surprised by the extent and the subjectiveness of the very necessary "ping editing" step. The across-track depth profile from every ping was displayed on a SUN work station (typically 10 or so at a time, stacked) and the operator made arbitrary judgements about which beams were correct and which were spurious. Sometimes this was obvious, often it was not. Typically as many as 20% of the recorded beams were deleted in this tedious and time-consuming process. Even after this editing step, first plots of the data as swaths along track displayed numerous artifacts (square seamounts and linear across track scarps corresponding to data gaps).
The data quality is clearly far inferior to conventional 45 degree Seabeam data. Improvements in our results may be possible with further editing but this necessarily will continue to be a subjective process. Doubts will remain about what is real and what is not.

We were informed that this performance level was typical of the system.

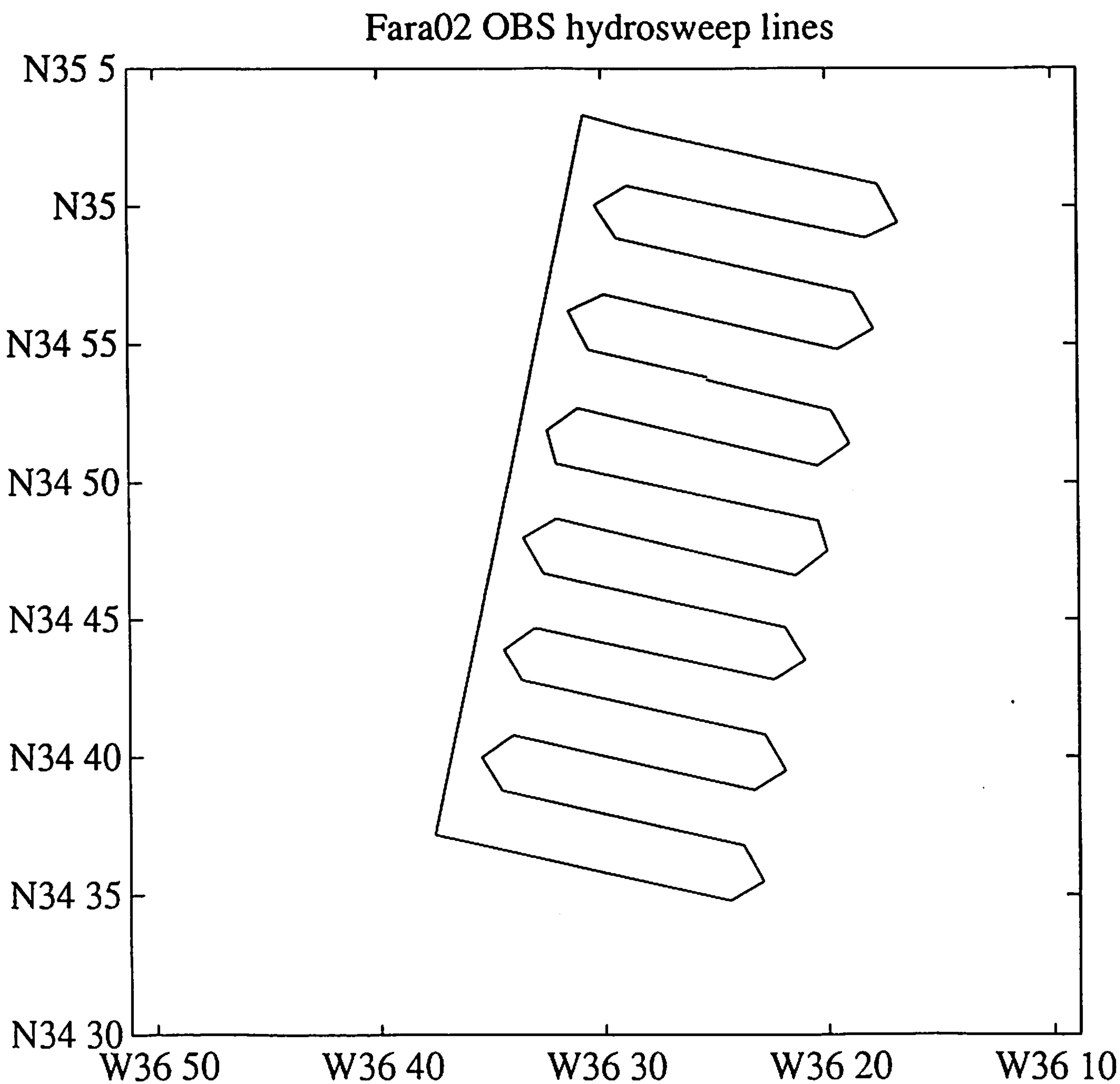


FIGURE A19.1 Configuration of the tracks for the Hydrosweep multibeam bathymetry survey over the OBS network.