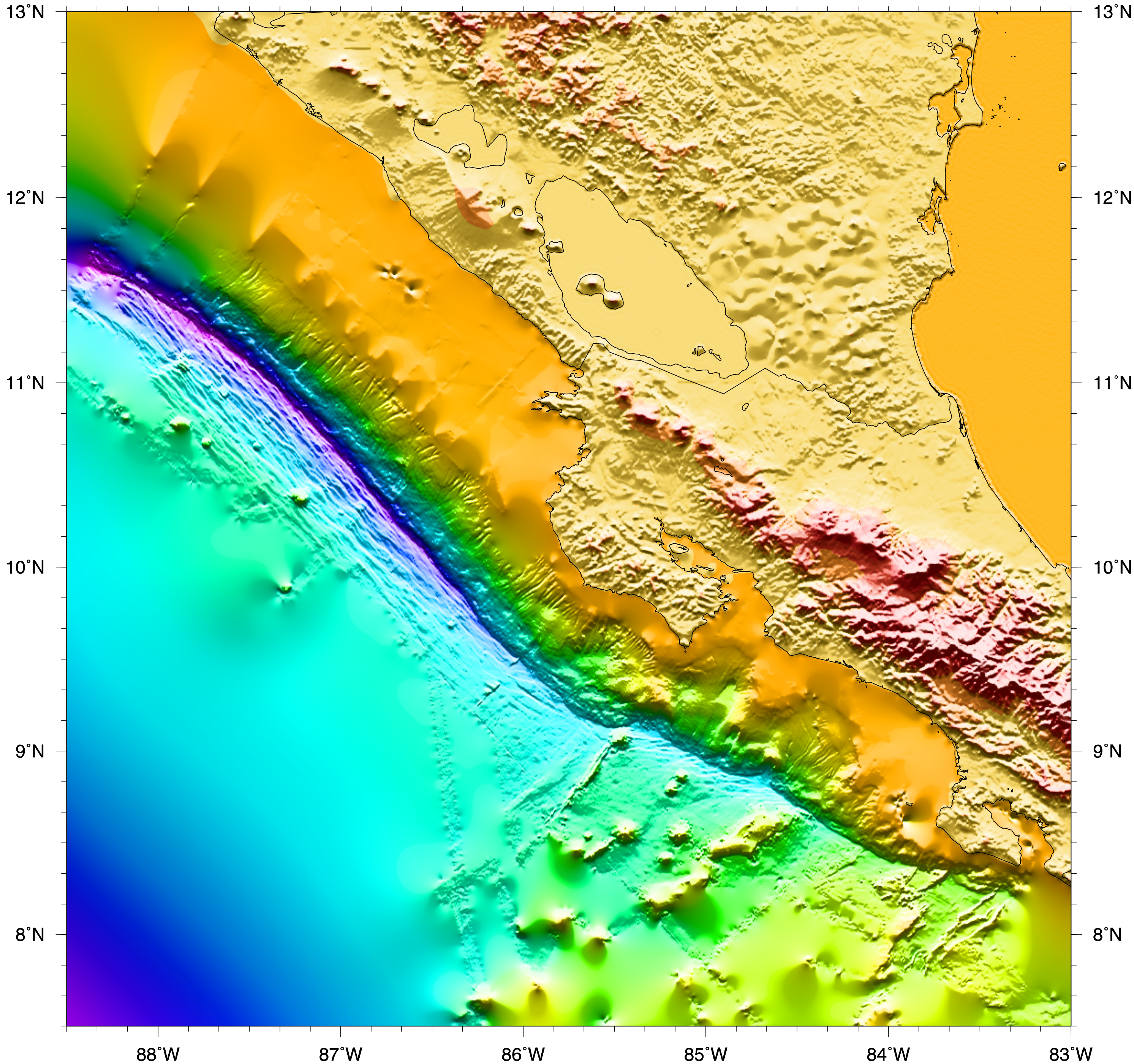
NicSeis Cruise Report
EW00-05, May-June 2000



NICSEIS Cruise Report

EW0005

SUMMARY

From 26 May to 27 June 2000 we used the R/V Maurice Ewing to collect an extensive seismic reflection and refraction data set off the Pacific margin of Nicaragua and northwestern Costa Rica (Figure 1). Our data set spans the Sandino forearc basin, the trench slope, the Middle America Trench, and the Cocos plate to the outer bulge. We recorded more than 2800 km of 240-channel seismic reflection data and ~580 km of OBH and land station refraction data. The wide-angle data set includes 16+ successful land deployments on two lines and 39 successful OBH deployments on three lines.

OBJECTIVES

The objectives of this project are to support the goals of the SEIZE and Subduction Factory initiatives of MARGINS. Specific objectives of SEIZE include: 1) the physical nature of asperities along the seismogenic zone; 2) the nature of tsunami earthquakes; 3) primary controls on the updip and downdip limits of the seismogenic zone in subduction thrusts. Objectives of the Subduction Factory are to understand the reasons for the strong geochemical variability of subducted products along the volcanic arc, as well as the importance of subducted carbonates. What is the role of structural variability in the lower plate as it subducts along the margin? Does increasing fault displacement moving northward from Costa Rica influence the seismogenic and subduction factory processes?

To understand these objectives, we designed a seismic reflection and refraction program, with auxiliary hydrosweep bathymetry, gravity, and magnetics. We planned to image the subduction interface both within and outside of the hypocentral zone of the 1992 tsunami earthquake. Fault zones, diapiric structures, and anomalous reflection amplitudes will suggest zones of active fluid expulsion where changes in plate boundary pore fluid pressure may occur. BSRs will provide a rough control on margin heat flow, which in turn can be used to estimate temperature along the plate boundary, limiting zones of various dehydration reactions and pore fluid pressure. We also expect to characterize the subducting Cocos plate from the outer bulge to below the margin wedge. Variation in the style and amount of bending related deformation may be critical for Subduction Factory "slab signals" from fluids and sediments and equally important for fault zone processes and the development of a seismogenic plate boundary. For example, we expect to trace lower plate faults beneath the margin wedge to evaluate their importance as irregularities along the subduction interface and their potential for moving the youngest lower plate sediment deeply beneath the margin toward the melting zones of the volcanic arc. We also will focus on whether any frontal accretion or sub-wedge underplating occurs, as opposed to subduction erosion of the upper plate.

EW0005 NicSeis Cruise Participants

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R/V Maurice Ewing Science Staff

Chris Leidhold	Science Officer
Karl Hagel	Electronics Technician
Jeff Turmelle	System Administrator/Data Reduction
John DiBernardo	Senior Airgun Technician
John Byrne	Senior Airgun Technician
Megan Flanagan	Airgun Technician
Winston Seiler	Airgun Technician

R/V Ewing Senior Crew

James O'Laughlin	Master
Earl Mayhofer	First Mate
Jeffrey Sylvia	Second Mate
Richard Thomas	Third Mate
Stephen Pica	Chief Engineer

NicSeis Cruise Narrative EW00-05

24 May We arrived in Puntarenas late in the afternoon and found that the R/V Ewing was not moored to the pier but anchored out. The ship's agent and Captain O'Laughlin had made arrangements for regular launch trips from shore to the ship, so we boarded the launch and ~15 minutes later we were on the R/V Ewing. This included all of the new science party except for Carlos Guzmán and Arnim Berhorst. Carlos arrived from Nicaragua later in the day.

25 May This day was spent getting moved in and installing our computer systems. This task was only partially completed due to absence of the system manager who was taking some much needed time off. Arnim Berhorst arrived after finally retrieving his lost luggage.

26 May We moved to the pier at about 08:30 and loaded ship stores and fresh water. We left the pier at 11:30 and headed toward Nicaragua. At 21:45 we stopped to perform an OBH release test. This required two wireline drops to test all 14 release mechanisms.

27-28 May To allow time to prepare the OBHs we performed a Hydrosweep program. We spent about 34 hours to fill in gaps in the GEOMAR bathymetry data set near the Middle America Trench and the adjacent Cocos Plate seafloor. This work was mostly successful except for a period of 5 hours when the hydrosweep results were very poor. This was due to a hydrosweep problem or possibly the 11 kt. speed was too high. The hydrosweep program was completed at 16:23 and we started deploying OBHs along line NIC 20.

29 May The OBH deployment continued until 02:49 with the deployment of OBH #14 about 9 km off the coast of Nicaragua, near the small port of San Juan del Sur. At this time the process of deploying the streamer started. Some streamer work was required including changing one of the sections and making some other minor repairs. The streamer and airguns were deployed by ~14:00 and we started the first profile, NIC20H at 15:40. This profile was enhanced for OBH and land instruments by shooting at 60-second intervals. We first tried to shoot on 125 m distances computed from GPS, but this apparently resulted in problems (missed shots, mangled headers) so we were force to shoot on randomized time.

30 May Line NIC20H was completed at 17:40 at the southwest end of the line. The ship continued a short distance farther to do some equipment testing. At this point (20:43) the ship and streamer turned and started to reshoot the line. Again we tried to shoot on distance, but there were header problems. We switched back to shooting on time at a 20 second shot interval, and speed of 4.86 kt. to simulate 50 m shot intervals.

31 May We continued shooting line NIC20 and completed it at 19:53. We continued shooting along connector line NIC15 parallel to the coast and then turned to shoot line NIC14 at 21:16. Line 14 is an extension of the BGR line 41. The plate boundary reflection on BGR 41 indicated that it would be necessary to record more than 16 seconds. We changed parameters to travel

at 4.0 kt and fire at 24 second intervals. This allowed for a ~50 m shot interval and a 20 second record length.

1 June Line NIC14 was completed at 03:07. We turned to southeast and transited to the start of line NIC10. Line 10 started at 05:52 heading southwest from near the Santa Elena Peninsula. Line 10 was acquired at 4.86 kt, 20 second shot interval, and 16-second record length. Line NIC10 completed at 18:40. We called the connecting line "Test" to again test shooting on distance—it seemed to work, so we started line 22 shooting on distance. Start line NIC22 at 22:16. We experienced a problem with the recording system that went undetected for over 1 hour. Line NIC22 resumed recording ~12 km seaward of the trench.

2 June Line NIC22 completed at 08:36. Turned onto line NIC26 headed southwest and line started at 09:32. Speed and course changes were required to avoid traffic. At 13:14 several (5-6) shots were missed—had to stop and restart shooting. Line NIC26 was completed at 19:15 and line NIC24 was started at 20:00.

3 June Line NIC24 continued--various airguns were out at different times. Line completed at 04:49. Line NIC28 started at 05:43. Airgun problems occurred near the end of the line. Line completed at 17:30 turning for transit to line NIC30. Line NIC30 started at 17:30.

4 June Line NIC30 completed at 08:31. Start line NIC31 (connector) at 09:11 and end at 10:41. Start line NIC40 at 11:47.

5 June Line NIC40 completed at 02:10. We recovered the streamer and airguns and transited to station OBH 1 for recovery. The instruments were recovered through the day.

6 June Instrument recovery on line NIC20 completed at 04:08. We turned on the hydrosweep and headed across the shelf to begin swath mapping. The swath mapping added coverage on the trench slope between the primary areas mapped off Costa Rica and Nicaragua by previous GEOMAR cruises.

7 June We terminated the hydrosweep surveying at 09:15 and proceeded to OBH station 15 to begin deployment along line NIC50. Deployment started at 10:34 and advanced to the northeast. Deployment was completed at 22:15 at OBH station #28 near the Nicaraguan coast. Streamer deployment was started after turning moving to a safer distance from the coast to avoid accidents with fishing boats.

8 June Started shooting line NIC50H at 07:30. We had various problems with the tape drive 0 and missed some shots. Later there was a problem with one of the streamer birds or there was something caught on the streamer because the middle portion rose to the surface. We increased speed from 4.0 kt to ~4.5 kt and the streamer went down some but still was uneven. Later we launched the boat and Chris, Karl, and Jeff went to investigate. They did not find anything on the streamer and returned to the ship. After this the birds were able to maintain the streamer at the desired depth of 10 meters.

9 June Line NIC50H was completed at 06:47. The ship turned 180° (to northeast) and started line NIC50 at 09:30.

10 June Line NIC50 was completed at 05:55. The ship turned 90° and headed toward line NIC60. We started line NIC60 at 08:00, but a short time later we encountered fishing equipment and the streamer became unbalanced. Although the line was intended to be acquired at 24 second shot intervals with 20 second record length, we speeded up to 4.5 kt. This allowed the streamer to come down, but there was still a significant hump. We decided not to shoot a whole line this way with questionable data. Accordingly, we decided to bring in the airguns and streamer and started that process after lunch. The streamer was on the ship by 16:30 and a noisy section was replaced during the process. Following streamer recovery we transited to the site of OBH 28 and recovered the instrument.

11 June OBH instrument recovery continued through the early morning hours and was completed by 08:30. From 09:00 to 10:00 an engine room repair was made. At 10:00 streamer deployment was started. The streamer and airguns were deployed by 16:30 and shooting on line NIC54 started at 17:23.

12 June Line NIC54 was completed at 00:54, and Line NIC56 was started at 01:32. Line NIC56 was acquired to the southwest and was completed at 09:05. Line NIC52 started at 10:41 and was completed at 20:14. We had some difficulty maintaining speed due to strong headwinds. The winds have typically been from the northeast and the current has typically been from the southeast. This situation required using the third engine for additional propulsion. From the end of line NIC52 we transited to line NIC60 and resumed acquisition that had be stopped on 10 June. We did not extend the line landward to include the entire original extent of the line, however we did cover ~125 km from the outer shelf to the Cocos plate bulge.

13 June Line NIC60 was completed at 12:40 and we turned northwest to begin line NIC70. Line NIC70 was started at 15:10. This turned out to be a difficult maneuver--with the strong northeast wind and the southeast current, the ship turned only slowly and overshot the line by ~500 m. Again the strong headwind made it difficult to maintain speed. In the early evening the third engine was added for additional propulsion.

14 June Line NIC70 was completed at 04:48 and we turned northwest toward line NIC84. During this transit Jeff Turmelle tested shooting on distance again with a new fix from Joe Stennett. Finally it seemed to work! NIC84 was started at 07:06 shooting on distance and it was completed without difficulty at 16:51. Line NIC86 was started at 17:58 after slightly extending the turn to make a mechanical repair. Today the wind has not been a significant problem.

15 June Line NIC86 was completed at 01:07 and line NIC82, progressing to the southwest, was started at 02:01. Shortly after the start of NIC82 there were compressor problems, which resulted in missed shots. To alleviate the problem, we reduced the number of airguns firing. The number of airguns varied from 4 to about 14 for a few hours while only one compressor was consistently available and another online intermittently. By about 06:00 the compressor situation stabilized with 2 working consistently. This allowed use of the full 20-airgun array again. Line NIC82 was completed at 14:50. This

line and the subsequent NIC80 extended over 55 km across the Cocos plate. After the turn, line NIC80 was started at15:41, progressing to the northeast.

16 June — As we reached 50 km from the planned end of NIC80, we briefly suspended recording, slowed the ship speed to 4.00 kt, and then increased the record length to 20 seconds. This was done to record the plate boundary reflection, if possible, beneath the Sandino Basin. The basin fill extends to as deep as 8-10 seconds two-way travel time and thus tends to delay the arrival of the deeper plate boundary reflection. Line NIC80 was completed, slightly prematurely, at 13:00 to avoid fishing equipment lying in the path of the line. The turn started about 3 nm before the planned waypoint. We experienced rainstorms just prior to the turn and after turning to connecting line NIC80C. NIC80C is approximately 45 km long so we recorded 20 seconds of data while traveling at 4.0 kt and shooting on distance at 50-meter intervals. Shooting on distance has been used successfully since line NIC84.

17 June — Line NIC80C was completed at 01:36 and we turned onto line NIC90 to the southwest. We continued for the first 50 km of this line at 4.0 kt to record for 20 seconds. During this time we noticed strong noise on the streamer QC display. Some of the noise was due to an airgun that had been swept over the streamer by swells coming across our path. After turning off the airgun and eventually bringing it in we found that some of the noise persisted. Apparently, this noise is generated in areas of shallow water and may be converted shear waves. After passing over the deep portion of the Sandino Basin we reduced record length to 16 seconds, increased speed to ~4.86 kt, all while maintaining a shot distance of 50 m triggered on distance. As we neared the trench we reduced the speed to 4.5 kt. to reduce noise. Line 90 was completed at 13:48 and we turned to line NIC90C. We continued to be concerned about the streamer noise so we increased the depth to 12 m. This seemed to help some, but there were still some noise problems. Line NIC90C was completed at 18:09 and we turned northeast onto line NIC100.

18 June — On the landward ~50 km of Line NIC100 we again switched to 20 second record lengths and 4.0 kt speed. The line was completed at 13:31 and we turned onto line NIC100C. Line 100C was completed at 18:11 and we turned southwest onto line NIC110. BOL NIC110 was at 18:24. We started this line recording for 20 seconds over the deep Sandino Basin. After the initial landward segment, we switched to 16-second record length and speeded up.

19 June — Unfortunately, the computer controlling the seismic system had a SCSI bus error and failed to record data for about 20 minutes. As this was over the lower trench slope, a key target area, we decided to break off line NIC110 and reshoot the missed portion—NIC110X. The ship turned back to the line somewhat early and missed the waypoint to get back on the line. After all, there may still be a small gap in this line. We completed line NIC110X at 18:36 and recovered the streamer. During streamer recovery we found the causes of some of the noise problems we had observed: One of the SRDs was nearly detached from the streamer and one of the birds was attached at the rear and with the safety cord in the front. This had apparently caused significant noise and prevented the bird from effectively controlling the depth.

20 June After the streamer was recovered we transited toward OBH station #29 for deployment. Enroute to the site we acquired hydrosweep bathymetry along tracks extending the coverage in the northwest part of the survey area. OBH #29 was launched at 09:36 and OBH #41 was launched at 21:55 to finish the deployment. We immediately deployed the tailbouy and started deploying the streamer.

21 June The streamer was deployed by 02:30 and the airguns were made ready. By 04:19 line NIC125 was started with intended speed of 4.0 kt. and shot distance of 125 m. This speed and shot distance leads to a time between shots of just over 60 seconds and results in significantly lower noise on the OBH records. Unfortunately this also reduces the stacking fold of the MCS data recorded simultaneously, but the resulting gathers are still 20-30 fold. During acquisition along this line the current was largely parallel to the line, so that it was difficult to control the streamer. Eventually we increased the velocity to 4.4 kt to increase the speed through the water. This reduced the time between shots to about 55 seconds.

22 June Line NIC125 was completed at 04:30 and we turned to line NIC125C. At 06:10 we stopped data acquisition to clean tape drive 0. This tape drive had repeatedly failed during lineNIC125, sometimes recording 20 shots per tape (out of >80 possible) or sometimes failing immediately, resulting in loss of data before drive 1 was ready. At 08:42 line NIC115 was started. At 13:00 we started to encounter increased traffic and at 19:42 we had to move off the line and slow down. This was not a big problem, and eventually we resumed the planned course and speed.

23 June Line NIC115 was completed at 09:00, and the magnetometer was also turned off to begin equipment recovery. Sequentially, the magnetometer, airguns, and streamer were recovered as we headed toward Line NIC125 to recover the OBHs. At 16:24 OBH 41 was recovered and we continued along the line to recover the remaining instruments.

24 June At 06:00 the last OBH, #29, was recovered. At this point we headed toward the lower slope section of line NIC70 to dredge the slump scarp in an attempt to recover material from the margin wedge. At 10:30 we arrived at the dredge site. The dredge was brought on board at 16:30 with a good collection of rocks. The assemblage of limestone, chert, and basalt suggests that we may have been successful in sampling the margin wedge. Immediately after the dredge was recovered the ship headed south to a position seaward of the trench at the limit of the existing hydrosweep data set. At that point we turned parallel to the trench to the SE and added one more swath of bathymetry to the data set as we headed toward Panama.

25, 26 June In transit to Panama

27 June Arrived near Balboa in the early morning and anchored out to wait for a pilot. Arrived in port in the early afternoon--EW0005 completed.

ACQUISITION PARAMETERS AND INSTRUMENTATION

STREAMER

We used the full 6 km length of the Ewing's seismic streamer configured into 240 channels. We used 24 birds spaced throughout the streamer with 12 of the birds equipped with compasses for subsequent streamer navigation and analysis (Figure 2). The streamer was towed at 10 m depth on all but one line (NIC100), on which it was towed at 12 m to further reduce noise. The birds were generally able to control the streamer depth very well except in a extreme cases where (1) fishing gear with flotation was caught on the streamer, (2) one of the birds became partially detached from the streamer, so it could not function (and it made a lot of noise). The only other severe noise problem was when one of the SRD's (emergency flotation device for the streamer) became partially detached. Throughout the cruise various streamer sections became noisy and were replaced during subsequent streamer redeployments. In general, less than 5% of the channels had significant noise that may require killing during processing.

MCS DATA RECORDING

The R/V Ewing is equipped with a Syntrak 480-24 recording system. This system can record up to 480 channels, but we chose to configure it to record 240 channels at a 2-ms sample interval. For most of the data acquisition we recorded 16 seconds of data; however, on a number of lines we switched to a 20 second record length (many cases in mid-line). This may have been wishful thinking, but we thought that we saw arrivals (probably plate boundary reflection), which extended deeper than 16 seconds. This is reasonable given the proximity of the landward ends of these lines to the volcanic arc. For lines NIC20H and NIC50H we recorded for 20 second with a shot interval of ~60 seconds. For the MCS lines we attempted to maintain a 50 m shot spacing to end up with uniform numbers of traces and offsets in the CDP bins. In general we tried to maintain a speed of 4.86 kt to have a shot every 20 seconds at 50 m spacing. However, to record for 20 seconds and maintain the 50 m spacing we had to slow the ship to about 4.0 kt. Appendix 1 lists each line and how it was shot. At the start of the cruise we attempted to trigger the airguns on distance, but for a variety of reasons this failed and we gave up after a short time, instead shooting on time. Jeff Turmelle scoured the software that is supposed to calculate the distance and issue the fire command, and Chris Leidhold examined the system for problems. After several changes in the software and several subsequent tests, the system was finally capable of shooting on distance. Appendix 1 indicates whether each line was triggered on distance or time.

Although the acquisition control system and the streamer control system worked quite well during the cruise, we had continuous trouble with the tape drives. At the time of our cruise, the recording system was equipped with only two 3490 tape drives. These drives frequently would record on only part of a tape, 20 shots versus 40 to >80 shots possible, or sometimes they would fail completely causing loss of data. Data loss occurred when one drive finished a tape and the other drive refused to work and record the next shot. This meant that the "good" drive would have to finish rewinding, eject, and accept a new tape before recording would resume. This typically took several minutes and caused a loss of ~5 shots. Throughout the cruise we retensioned and cleaned the tapes before using them in the tape drives--this did not seem to make much difference. Eventually, about 2/3 of the way through the cruise, the retensioner broke and was not reparable on board. Appendix 2 contains a table, organized by line, showing reel number, shots contained on the reel, number of samples recorded, and the start time of the reel.

SOURCE ARRAY

Throughout the cruise our plan was to use a 20-airgun source array. Approximately 80-90% of the time we were able to use the full array; the airguns were reliable and the airgun technicians were very competent and quick to diagnose and repair problems. Our biggest problem with keeping 20 airguns in the water was in cases where the current and wind require the ship to "crab" in order to maintain course and the airguns nearest to the streamer bumped it and even passed over it. This situation was exacerbated a few times when there were significant swells also coming across the array.

To reduce the bubble pulse and create a source signature with a relatively flat amplitude spectrum we modified the standard Ewing source array by including a slightly different set of chamber sizes and a somewhat different towing arrangement. The concept is to distribute the different airgun sizes as evenly as possible to maximize bubble cancellation. In addition, our target towing depth was 6.5 meters, which results in a significantly higher peak to bubble ratio than deeper tow depths without a large loss of energy. Other than brief periods when floats were lost or damaged, each airgun was connected to a float, to maintain the desired depth position regardless of ship speed and sea conditions, in addition to its towline to the ship. The airgun arrangement is illustrated in Figure 3 and the list of airguns used is given in Table 1. We arrived at this array configuration by using the program "Nucleus" to model the airgun array. Imtiaz Ahmed performed the modeling under the guidance of Kirk McIntosh and significant help from Nathan Bangs. Comparisons of our array with the Ewing Standard array and our array at greater depths are shown in Figure 4. We believe that this modified array performed well in the field and significantly reduced the bubble pulse compared to other data sets we have seen. It also seems that the strength of the signal was generally sufficient with reflection penetration to > 16 seconds and refraction arrivals to > 140 km.

Important Note: The airgun positions listed in Table 1 are what we used in the modeling, and they are based on the positions the guns are attached to the ship or boom (y-direction), the length of the tow lines (x-direction), and length of the float lines (z-direction). It was clear during the cruise that especially the Y position of the airguns was variable depending on currents and sea conditions. In general, the airguns tend to tow closer together than their attachment points, but the actual deviation was not measured or accurately estimated. Airgun depth was also largely based on the towline configuration rather than direct measurements. Specifically, the lines connecting the airguns to the floats were measured to accommodate the desired tow depth, however, the pressure sensors on the airguns, which can be monitored on the ship during operations, were not able to provide a reliable absolute depth estimate. Instead, when they were working at all, they could be used to indicate only large relative changes in airgun depth.

NAVIGATION

The navigation control for this cruise was provided largely by the Y-Code, Tasmon GPS receiver. Previous analysis of Y-Code positions by Bangs, during EW9803, indicated that 95% of the positions lie within ±8 m. These tests were made while the R/V Ewing was tied to the dock. Unfortunately, the R/V *Ewing* was anchored a small distance off of Puntarenas, Costa Rica prior to EW0005, so a similar test could not be made. However, in spite of the inherent instability of being at anchor and subject to regular tidal fluctuations, we can get a rough idea about the Y-Code positioning accuracy. Figure 5 shows the GPS positions during 24 May 2000. The different colors each span two-hour time periods. Some of these periods include all or part of a tidal transition but some include periods where the tidal direction was consistent. Of these, period 6, marked by green dots, shows a variation over the 2-hour time period of just over 10 m. Although far from a perfect test, this suggests that the accuracy from the Y-Code receiver should be near the previously estimated ±8 m level and almost certainly within the ±16-m accuracy expected from general Y-Code specifications.

OBH OPERATIONS

Our partners from GEOMAR, Kiel, Germany, performed the OBH program during NicSeis. Their group consisted of A. Berhorst, C. Walther, and C. R. Ranero. They used both ocean bottom hydrophones (OBH) and ocean bottom seismographs (OBS) during this cruise.

A total of 10 OBHs and 4 OBSs were available for EW00-05. This type of instrument has proved to have a high reliability; and during this cruise the 1450th successful deployment was made. Altogether 41 sites were occupied during the EW00-05 cruise. Plots of all of these records are included in Appendix 3. These data are of variable quality, with particularly good results on line NIC20H. On this line arrivals are visible from > 140 km and should sample both the upper plate and lower plate to significant depth.

The principle design of the instrument is shown in Figure 6. The design is described in detail by Flueh and Bialas (1996). The system components are mounted on a steel pipe which holds the buoyancy body on its top. The buoyancy is made of syntactic foam and is rated, as are all other components of the system, for a water depth of 6000 m, except for the pressure cylinders holding the recording electronics. Here, various models are available for variable depths (2500 m, 3000 m, and 6000 m). Attached to the buoyant body are a radio beacon, a flash light, a flag and a swimming line for retrieving from aboard the vessel. The hydrophone for the acoustic release is also mounted here. The release transponder is a model *RT661CE* made by *MORS Technology*.

Communication with the instrument is possible through two transportable transducer systems, and even at high speed and ranges of 4 to 5 miles release and range commands are successful. For anchors, we use pieces of railway tracks weighing about 40 kg each. The anchors are suspended 2 to 3 m below the instrument. The sensor is an *E-2PD* hydrophone from *OAS Inc.*, and the recording device is a *MBS recorder of SEND GmbH*, which is contained in its own pressure tube and mounted below the buoyant body opposite the release transponder (see Figure 5).

Marine Broadband Seismic Recorder (MBS)

The so-called *Marine Broadband Seismic recorder (MBS;* Bialas and Flueh, 1999*)*, manufactured by *SEND GmbH*, was developed based upon experience with the DAT based recording unit Methusalem (Flueh and Bialas, 1996) over the last few years. This new recorder avoids a mechanically driven recording media, and the PCMCIA technology enables static flash memory cards to be used as unpowered storage media. Read/write errors due to failure in tape handling operations should not occur with this system. In addition, a data compression algorithm is implemented to increase data capacity. Redesign of the electronic layout enables a decreased power consumption (1.5 W) of about 25% compared to the *Methusalem* system. Depending on the sampling rate, data output could be in 16 to 18 bit signed data. Based on digital decimation filtering, the system was developed to serve a variety of seismic recording requirements. Therefore, the bandwidth reaches from 0.1 Hz for seismological observations to the 50 Hz range for refraction seismic experiments and up to 10 kHz for high resolution seismic surveys. The basic system is adapted to the required frequency range by setting up the appropriate analog front module. Alternatively, 1, 2, 3 or 4 analog input channels may be processed. Operational handling of the recording unit is similar to the *Methusalem* system or by loading a file via command or automatically after power-on. The time base is based on a DTCXO with a 0.05-ppm accuracy over temperature. Setting and synchronizing the time as well as monitoring the drift is carried out automatically by synchronization signals (DCF77 format) from a GPS-based coded time signal generator. Clock synchronization and drift are checked after recovery and compared with the original GPS units. After software preamplification the signals are low-pass filtered using a 5-pole Bessel filter with a -3 dB corner frequency of 10 kHz. Then each channel is digitized using a sigma-delta A/D converter at a resolution of 22 bits producing 32-bit signed digital data. After delta modulation and Huffman coding the samples are saved on PCMCIA storage cards together with timing information. Up to 4 storage cards may be used. Currently, up to 440 MB per card are available. Data compression allows more than 2 GB data capacity. Recently technical specifications of flashdisks (disk drives of PCMCIA technology) have been modified to operate below 10 °C, therefore 1 GB drives are now available for data storage. After recording the flashcards need to be copied to a PC workstation. During this transcription the data are decompressed and data files from a maximum of four flash memory units are combined into one data set and formatted according to the PASSCAL data scheme used by the *Methusalem* system. This enables full compatibility with the established processing system. While the *Methusalem* system did provide 16 bit integer data, the 18-bit data resolution of the *MBS* can be fully utilized using a 32-bit data format.

QUALITY CONTROL

The quality control procedures employed during the EW0005 consisted primarily of watchstander activities and preliminary seismic processing and plotting. The watchstanders were responsible for monitoring all the basic seismic acquisition parameters: streamer depth, noisy channels, airgun depth, airgun miss-firing, airgun timing errors, compressor performance (air pressure supplied to airguns), ship speed, distance between shots, etc. Other than a few specific occasions, the streamer maintained very consistent depth. However, there were consistently several bad or noisy traces during each line and these were noted by watch standers. The airgun operations were observed carefully by watchstanders and by the on duty airgun technicians. In most cases, when a watchstander became aware of an airgun-related problem the airgun technicians were already preparing to fix it. In general the assorted problems that we experienced were below the threshold necessary to stop operations. Only on line NIC60 did we terminate acquisition due to severe noise problems and on NIC110 we circled back on line after a computer failure cause a long period of missed shots. As the cruise went on we displayed near trace gathers or stacks, selected shot gathers, and subsequently produced brute stacks and water velocity FK migrations (see sequence below). These products allowed us to review data quality throughout the cruise.

ONBOARD SEISMIC AND HYDROSWEEP PROCESSING

Seismic Processing. We performed preliminary seismic processing of all the primary multichannel seismic data during the cruise to insure adequate data quality and to allow changes in our acquisition program in response to the results. The data processing was in the "quick and dirty" mode, with no trace editing, assumed 50 m shot spacing, very coarse velocity picking, and constant velocity FK migration. We primarily used the FOCUS package to process the data, but some tasks were performed by SIOSEIS and some parameter testing and more detailed processing was performed by Barrie Taylor using the ProMax package. The typical processing sequence during EW0005 is listed below:

1. Read SEG-D data on 3490E cartridge with SIOSEIS program segdin and output SEG-Y disk file. Both input and output have 2 ms sample intervals.
2. Using FOCUS, read SEG-Y disk file (program gin), apply antialias filter and resample to 4 ms sample interval, write both SEG-Y and FOCUS output files.
3. Write the SEG-Y data to 4 mm DDS3 tape using program xsegy.
4. Plot near trace section or stack of ~5 near traces in each CDP (no NMO applied).
5. Plot every 100th shot for QC purposes.
6. Apply geometry assuming 50 m shot intervals.
7. Create subset of CDPs (5 every 400-500) and use for velocity analysis and picking mutes
8. Sort to CDP, apply NMO, apply mute, stack (60 fold), filter (3-8-60-80), 1000 ms AGC and plot.

7. FK time migration at a constant velocity of 1490 m/s, apply filter, AGC, and plot.

Note: We had initially planned to read SEGD disk files with FOCUS. However, we found that the header information in the first data reels was scrambled. We assumed that the problem was with FOCUS being unable to interpret the extended SEGD header properly. In hindsight, we realized that the seismic system was producing scrambled headers, apparently as a result of trying to shoot on distance and possibly related to the long record lengths.

Some examples of on board processing are shown in figures 8, and 9. These plots, from lines NIC20 and NIC40, show the typical quality of the shipboard results (although these are very small plots!).

Hydrosweep Processing. Jeff Turmelle performed initial standard hydrosweep processing. These data were subsequently given to Cesar Ranero, so that they could be integrated with the existing GEOMAR data set. Cesar used the MBSystem software to make a first attempt to "clean" the data and to make water velocity corrections so that the data sets would be most consistent. Cesar produced maps incorporating new data periodically throughout the cruise, so we could examine the coverage and data quality, use the maps to plan OBH deployments, and determine the optimum locations for additional swaths.

SHIPBOARD OBSERVATIONS OF THE DATA

All 11 major dip lines across the margin and the 10 auxiliary dip lines showed the following broad structure.

1) The incoming plate is increasingly offset by normal faults as it enters the trench. Displacements vary from barely measurable to 500 m or more. The faults are almost parallel to the trench, though they intersect the upper plate at a small angle. Hydrosweep imaging shows that these trends continue to the upper plate, indicating that the subduction of the trench normal faults is responsible for the production of bathymetric trends in the upper plate. Several seismic lines document that subducted fault scarps with significant offset often underlie bathymetric highs on the lower slope.

2) Many of the seismic lines can follow the half-graben structural morphology of the lower plate well beneath the upper plate. This observation will have significant implications for understanding both seismic behavior off Nicaragua and the transfer of materials and chemistry passed the margin to the arc.

3) On many of the main profiles, the downgoing plate can be traced to depths in excess of 16 s, or close to 40 km depth. It is likely that we are imaging the entire extent of the seismogenic zone. In combination with the OBH refraction data, we expect to be able to determine whether the downdip edge of this zone coincides with the base of the upper plate crust.

4) The outer shelf and upper slope on all profiles is cut by normal faults. Usually a change in dip direction is noted, with landward dips dominating in the faults closer to land and seaward dips in the more seaward located faults. In places both types occur, either in crosscutting relationships or seen in changes in vertical sequence. Often irregularities in the top of the basement prism surface are related to these normal faults under the shelf and upper slope. On the lower slope thrust faults commonly cut this interface and continue through the sedimentary apron.

5) On all profiles, the top of prism reflection can be traced to within 1-2 km of the trench, and it appears most likely on most lines that the intervening material is slope apron rather than a frontally accreted wedge. On one line (NIC90) a small turbidite basin occurs in the trench and this line appears to show a small amount of frontal accretion. The fact that the basement rocks thin to a narrow wedge near the trench suggests that subduction erosion may be important here.

6) Many profiles show foreset beds with prominent unconformities at the outer shelf and upper slope areas, suggestive of regional subsidence.

7) On profile 70, the basement surface appears to crop out or come very close to the sea floor. We dredged this section, recovering ~100 kg of rocks. Most of the rocks recovered are sedimentary. They include blocks of sandstone, shale, siltstone, possibly limestone, and metasediments. One phacoid of metashale was recovered. This block has a strong slaty cleavage. We made preliminary identifications of one sample of altered gabbro and another of red chert.

DEGREE TO WHICH CRUISE OBJECTIVES WERE MET

We have collected more seismic data than originally planned, with the addition of a long dip line crossing the northernmost part of the Nicaragua margin. In addition, where we had originally planned to have only three lines completely cross the Sandino basin, we were able to acquire 6 lines across the basin. It was deemed important to do this because early on we realized that we could trace the downgoing plate to as much as 20 seconds travel time and the behavior of the plate interface is an important objective of this program. Existing industry data recorded only 7 seconds of data, and so does not aid that aspect of our research. To help achieve these additional goals, we ran only three auxiliary short lines each at two km spacing across the slope adjacent to lines 50 and 80, instead of the planned four auxiliary lines. We ran four such lines adjacent to line 20.

Additional hydrosweep data were acquired to fill in gaps in existing coverage, as proposed, and now, with our data and the existing GEOMAR data, we have nearly complete hydrosweep coverage off all of Costa Rica and most of Nicaragua. Northernmost Nicaragua still lacks complete coverage of the slope and trench regions.

Also unplanned was a dredge, as no previous data suggested that basement was accessible to dredging or shallow coring off either Costa Rica or Nicaragua. With the discovery of a possible outcrop on Line 70, we carried out a successful dredge, obtaining 100 kg of rocks.

A critical set of accompanying data involves three lines of OBH deployments, using 14 instruments. Of these, one turned out not to be functional and was not deployed on the third run. The dip lines where OBHs were laid out were shot at 125 m intervals, and then reshot for MCS at 50 m intervals. This provided excellent OBH and MCS coverage. The third OBH line was a strike line, situated on the upper slope. This was shot only at 125 m interval. Except for one instrument not functioning, the OBH acquisitions were a complete success and the preliminary data processed on the ship look good to excellent.

The two OBH dip lines were extended onshore with the emplacement of 9 land seismographs, made available to us by the PASSCAL program. Funding to carry out the land program was provided by the University of Texas (by funding students and thereby freeing monies) and the National Science Foundation.

In addition to the primary data, we collected magnetics, gravity, and 3.5 kHz data on all geophysical profiles and on hydrosweep runs. These data will provide powerful ancillary information about the magnetic and density structure of the margin.

In summary, cruise EW0005 (NICSEIS) was even more successful than originally hoped. We shot over 2500 km of seismic data and approximately 580 km of OBH refraction. Data quality as examined on board the ship was excellent. We were able to carry out brute stack and f-k migration on all the seismic lines while at sea, allowing us to see not only the data quality but also the subtleties of the crustal structure off Nicaragua.

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Figure 3. MCS data acquisition configuration.
Figure 4. Comparison of the R/V Ewing Standard airgun array and our modified array; A) Ewing "standard" array towed at 6.5 m; B) Modified array used for NicSeis towed at 6.5 m; C) Modified array towed at 8 m. Note the peak-to-bubble (P/B) ratio of 8.3 for our modified array versus 4.9 for the standard array, and 6.6 for the modified array at 8 m depth.
Figure 5. GPS fixes while at anchor off Puntarenas, Costa Rica. The different colors denote 2 hour time periods. Most of the movement can be attributed to tidal motions with some of the clustered fixes providing rough confirmation of our Y-Code position accuracy of ~10 m.
Figure 6. Diagram of GEOMAR ocean bottom hydrophone (OBH).
Figure 7. Map showing OBH locations and station numbers.
Figure 8. Line 20 preliminary migration from Middle America Trench to near the coast of Nicaragua (San Juan del Sur). Note the top of the subducting Cocos/plate boundary reflections.
Figure 9. Line 40 preliminary migration showing the Cocos plate (with seamount) to the trench, the slope, and about half of the shelf.
Figure 10. Photograph of material recovered by our dredge. Rocks included Late Cretaceous limestone and shale with associated chert and basalt.
Figure 11. Example of OBH data along line NIC20H. OBH 09 was deployed on the outer shelf portion of this transect.
Figure 12. Example of land data along line NIC20H. Station 102 was deployed just above (elevation78 m) the coastal town of San Juan del Sur on this transect.
Figure 13. Example of OBH data along line NIC50H. OBH 23 was deployed on the outer shelf portion of this transect.
Figure 14. Example of land data along line NIC50H. Station 203 was deployed near the village of La Trinidad (elevation 116 m) on this transect.

Table 1. Airgun array specifications

Gun #	X (m)	Y (m)	Z (m)	Volume (cu. in.)	Pressure (psi)
1	35.1	18.4	6.5	145	2000
2	44.2	16.7	6.5	350	2000
3	39.6	14.9	6.5	235	2000
4	35.1	13.2	6.5	305	2000
5	44.2	11.4	6.5	80	2000
6	39.6	9.7	6.5	640	2000
7	35.1	8.0	6.5	466	2000
8	44.2	6.2	6.5	145	2000
9	39.6	4.1	6.5	875	2000
10	35.1	2.1	6.5	200	2000
11	35.1	-2.1	6.5	250	2000
12	39.6	-4.1	6.5	850	2000
13	44.2	-6.2	6.5	200	2000
14	35.1	-8.0	6.5	235	2000
15	39.6	-9.7	6.5	500	2000
16	44.2	-11.4	6.5	466	2000
17	35.1	-13.2	6.5	350	2000
18	39.6	-14.9	6.5	260	2000
19	44.2	-16.7	6.5	120	2000
20	35.1	-18.4	6.5	145	2000

Other airgun array information and assumptions:
1. All airguns are **Bolt 1500-C** Longlife airguns, with varying chamber sizes.
2. The coordinate origin, (0,0) is at the center of the stern.
3. The guns on the booms are spaced at 5.7' or 1.74 m.
4. Gun pairs 8-9, 9-10, 11-12, and 12-13 are spaced at 6.7' or 2.04 m.
5. Guns 10 and 11 are 4.27 m apart.

Table 2. NIC20H OBH Information

INST.	LAT (N)			LON (W)			DEPTH	START			END			GAIN	REMARKS
	D	M	S	D	M	S	(m)	DAY	H	MIN	DAY	H	MIN		
OBH01	10	9	41.74	86	58	44.00	3370	150	19	11	158	20	12	9	
OBH02	10	19	17.14	86	49	2.66	4567	150	19	24	158	22	13	9	
OBH03	10	23	28.86	86	44	46.79	4242	150	19	40	158	23	18	9	
OBH04	10	26	31.96	86	41	41.3	3741	150	20	12	159	0	23	9	
OBH05	10	30	46.74	86	37	24.18	2141	150	20	21	159	1	22	9	
OBH06	10	33	52.04	86	34	17.8	1639	150	20	38	159	2	6	9	
OBH07	10	37	39.8	86	30	25.12	823	150	21	2	159	3	4	9	
OBH08	10	41	28.57	86	26	33.59	264	150	21	19	159	4	10	9	
OBH09	10	46	26.43	86	21	30.93	207	150	21	39	159	5	17	9	
OBH10	10	51	25.2	86	16	28.38	199	150	23	21	159	7	20	9	
OBH11	10	56	25.49	86	11	13.27	165	151	0	8	159	7	54	9	
OBH12	11	1	22.88	86	6	20.56	122	151	1	22	159	8	18	9	
OBH13	11	6	21.25	86	1	15.83	97	151	2	16	159	9	17	9	
OBH14	11	11	18.9	85	54	12.12	70	151	4	51	159	10	26	9	no data

Sampling rate: 4ms

Table 3. NIC50H OBH Information

INST.	LAT (N)			LON (W)			DEPTH	START			END			GAIN	REMARKS
	D	M	S	D	M	S	(m)	DAY	H	MIN	DAY	H	MIN		
OBH15	10	31	46.02	87	21	50.00	3221	160	13	8	164	14	45	9	
OBH16	10	38	29.66	87	16	39.08	3350	160	13	21	164	13	22	2	500m anchor
OBH17	10	42	7.57	87	12	49.64	4336	160	13	37	164	12	35	9	
OBH18	10	47	26.64	87	8	16.32	4850	160	14	15	164	11	14	9	no data
OBH19	10	51	10.82	87	5	4.08	3904	160	14	27	164	9	58	9	
OBH20	10	54	28.69	87	2	13.30	2971	160	14	45	164	8	31	9	
OBH21	10	57	46.30	86	59	22.34	1924	160	14	57	164	7	33	9	
OBH22	11	1	30.51	86	55	19.89	1074	160	16	49	164	6	37	9	
OBH23	11	7	45.62	86	50	46.89	311	160	18	56	164	5	35	9	
OBH24	11	13	29.91	86	45	51.28	190	160	19	12	164	4	40	9	
OBH25	11	19	12.82	86	40	48.64	161	160	19	57	164	3	41	9	
OBH26	11	24	59.00	86	35	50.00	112	160	20	35	164	2	42	9	
OBH27	11	30	45.17	86	30	48.46	59	160	21	57	164	1	49	9	
OBH28	11	36	30.84	86	25	47.94	26	160	22	5	164	0	40	9	

Sampling rate: 4ms

Table 4. NIC125H OBH Information

INST.	LAT (N)			LON (W)			DEPTH	START			END			GAIN	REMARKS
	D	M	S	D	M	S	(m)	DAY	H	MIN	DAY	H	MIN		
OBH29	11	28	51.85	87	15	42.7	506	173	13	32	177	12	7	9	
OBH30	11	23	23.28	87	10	23.97	616	173	14	31	177	11	3	9	
OBH31	11	17	53.17	87	5	7.31	601	173	15	15	177	9	56	9	
OBH32	11	12	27	86	59	45.84	500	173	15	7	177	8	58	9	
OBH33	11	6	56.47	86	54	26.86	561	173	15	57	177	7	43	9	
OBH34	11	1	27.21	86	49	7.84	686	173	16	6	177	6	32	9	
OBH35	10	55	55.76	86	43	47	685	173	16	14	177	5	29	9	
OBH36	10	50	30.72	86	38	28.99	485	173	16	47	177	4	21	9	
OBH37	10	45	0.74	86	33	14.88	640	173	17	12	177	3	11	9	
OBH38	10	39	30.96	86	27	54.66	450	173	17	28	177	2	3	9	
OBH39	10	34	25.49	86	22	37.26	477	173	18	29	177	0	51	9	
OBH40	10	28	29.71	86	17	20.44	914	173	19	17	176	23	47	9	
OBH41	10	23	2.02	86	12	2.03	444	173	19	24	176	22	35	9	

Sampling rate: 4ms

EW-0005 Puntarenas, Costa Rica - Panama

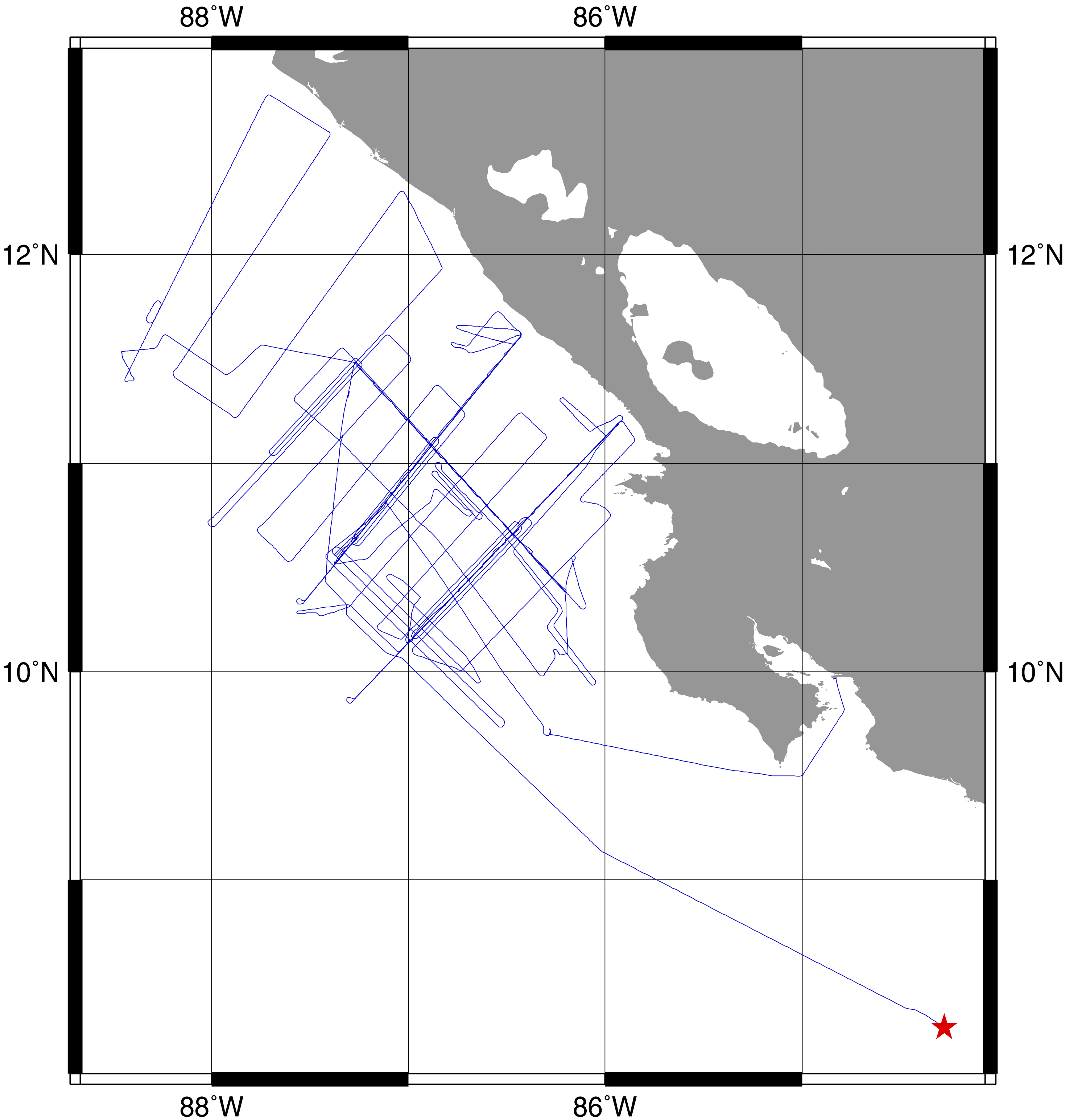


Figure 1

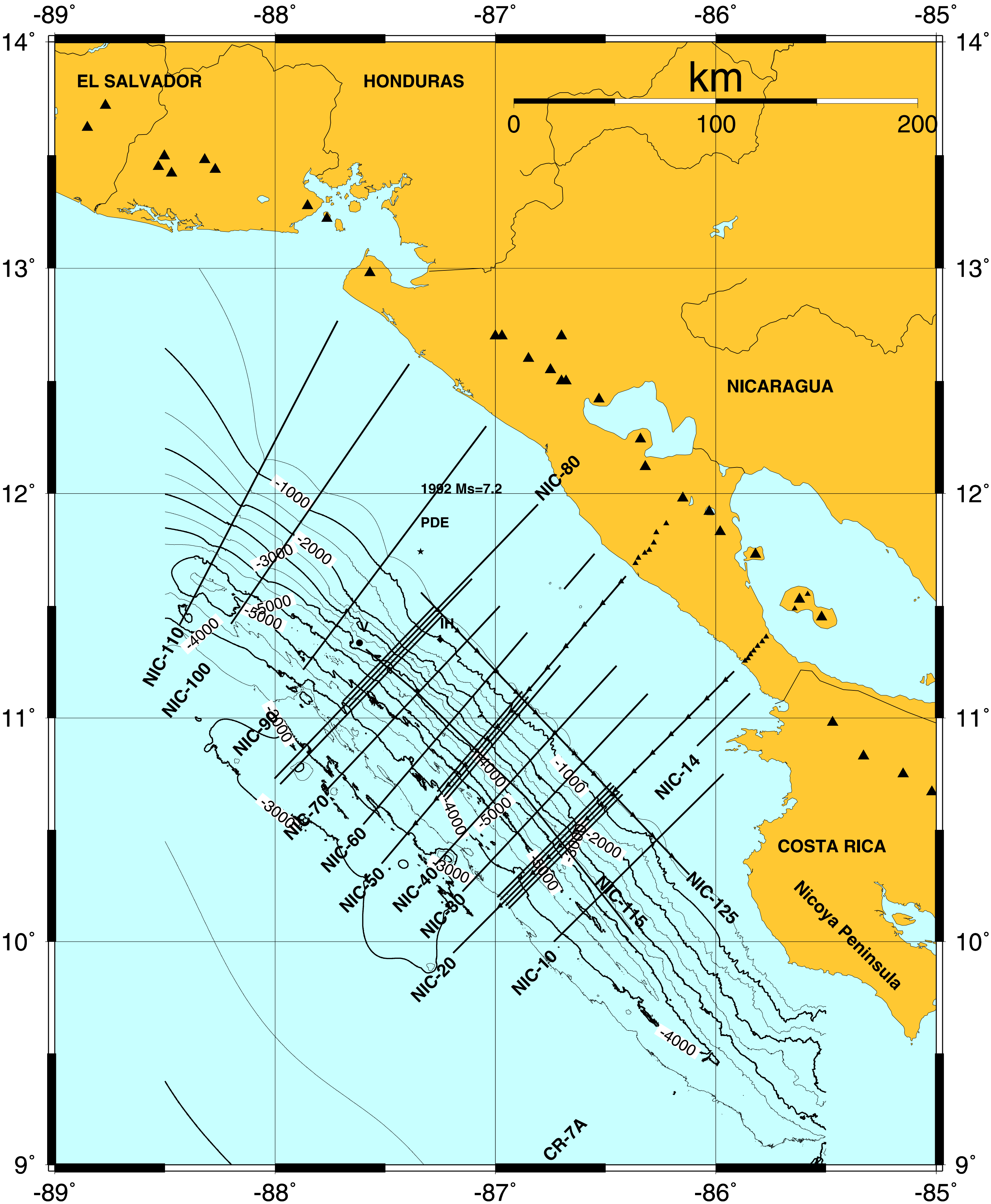

EL SALVADOR
HONDURAS
NICARAGUA
COSTA RICA
Nicoya Peninsula
km
0
100
200
1992 Ms=7.2
PDE
NIC-80
NIC-110
NIC-100
NIC-90
NIC-70
NIC-60
NIC-50
NIC-40
NIC-30
NIC-20
NIC-10
NIC-14
NIC-115
NIC-125
CR-7A
-1000
-2000
-3000
-4000
-5000
V
IH
-89°
-88°
-87°
-86°
-85°
14°
13°
12°
11°
10°
9°

Figure 2

MAURICE EWING SETBACK AND OFFSET DIAGRAM (Ew0005)

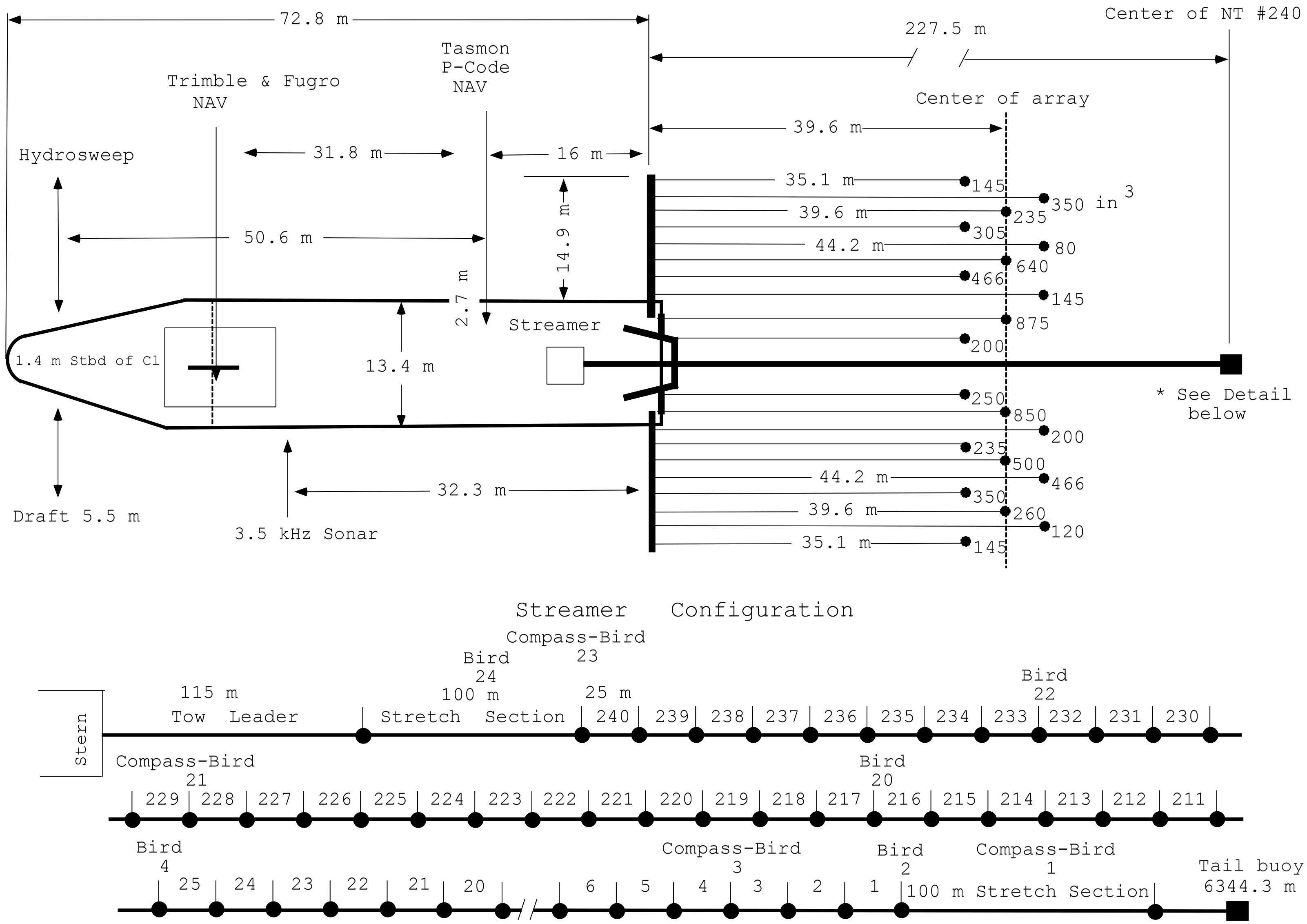


Figure 3

240 Channels, 40 Active Cans, 25 m Groups, 6000 m Active Sections,
Source to NT Offsets 187.9 m, source setback from Tasmon antenna 55.6 m.

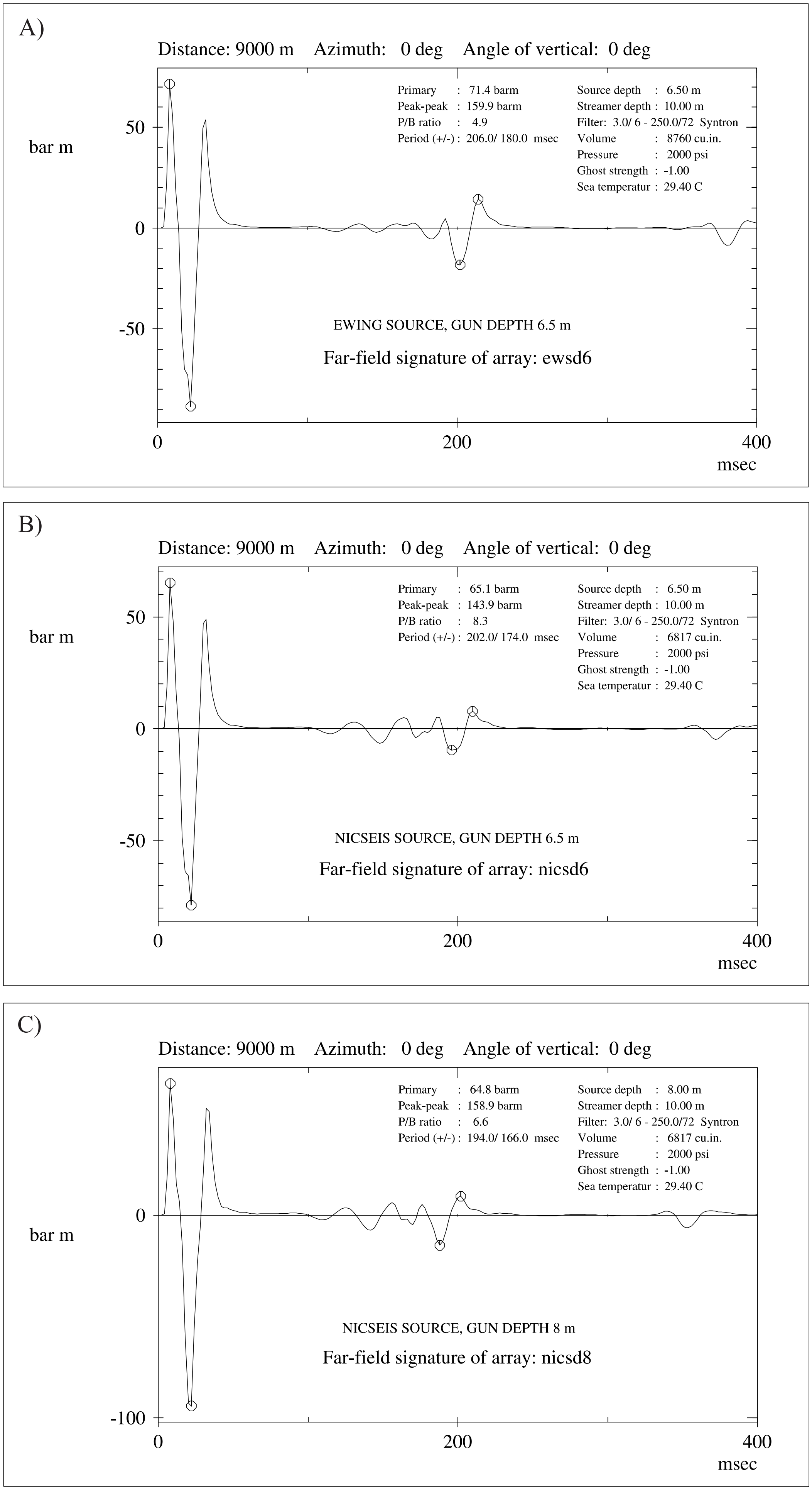

A)
Distance: 9000 m Azimuth: 0 deg Angle of vertical: 0 deg
Primary : 71.4 barm
Peak-peak : 159.9 barm
P/B ratio : 4.9
Period (+/-) : 206.0/ 180.0 msec
Source depth : 6.50 m
Streamer depth : 10.00 m
Filter: 3.0/ 6 - 250.0/72 Syntron
Volume : 8760 cu.in.
Pressure : 2000 psi
Ghost strength : -1.00
Sea temperatur : 29.40 C
bar m
50
0
-50
EWING SOURCE, GUN DEPTH 6.5 m
Far-field signature of array: ewsd6
0
200
400
msec
B)
Distance: 9000 m Azimuth: 0 deg Angle of vertical: 0 deg
Primary : 65.1 barm
Peak-peak : 143.9 barm
P/B ratio : 8.3
Period (+/-) : 202.0/ 174.0 msec
Source depth : 6.50 m
Streamer depth : 10.00 m
Filter: 3.0/ 6 - 250.0/72 Syntron
Volume : 6817 cu.in.
Pressure : 2000 psi
Ghost strength : -1.00
Sea temperatur : 29.40 C
bar m
50
0
-50
NICSEIS SOURCE, GUN DEPTH 6.5 m
Far-field signature of array: nicsd6
0
200
400
msec
C)
Distance: 9000 m Azimuth: 0 deg Angle of vertical: 0 deg
Primary : 64.8 barm
Peak-peak : 158.9 barm
P/B ratio : 6.6
Period (+/-) : 194.0/ 166.0 msec
Source depth : 8.00 m
Streamer depth : 10.00 m
Filter: 3.0/ 6 - 250.0/72 Syntron
Volume : 6817 cu.in.
Pressure : 2000 psi
Ghost strength : -1.00
Sea temperatur : 29.40 C
bar m
0
-100
NICSEIS SOURCE, GUN DEPTH 8 m
Far-field signature of array: nicsd8
0
200
400
msec

Figure 4

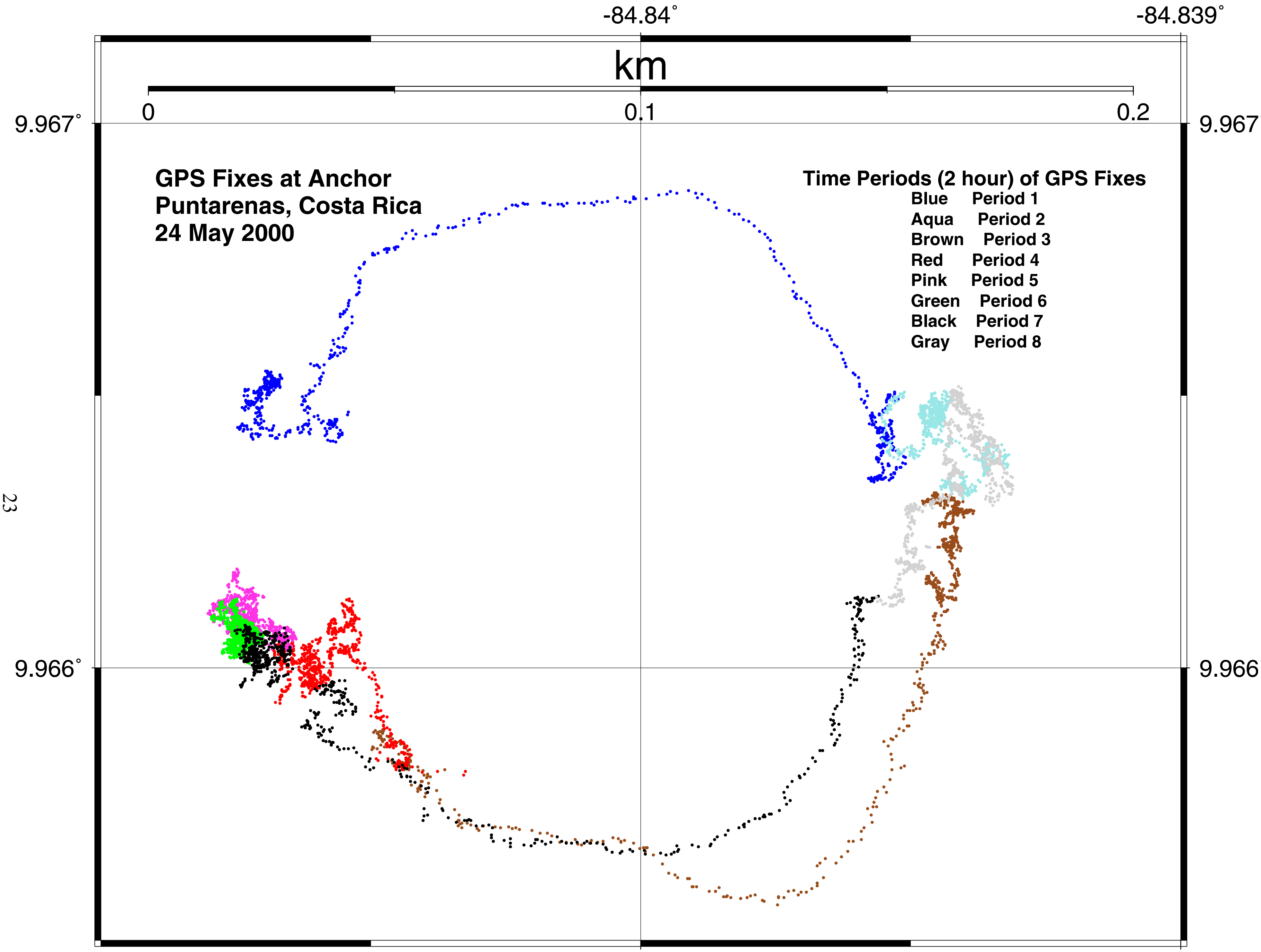
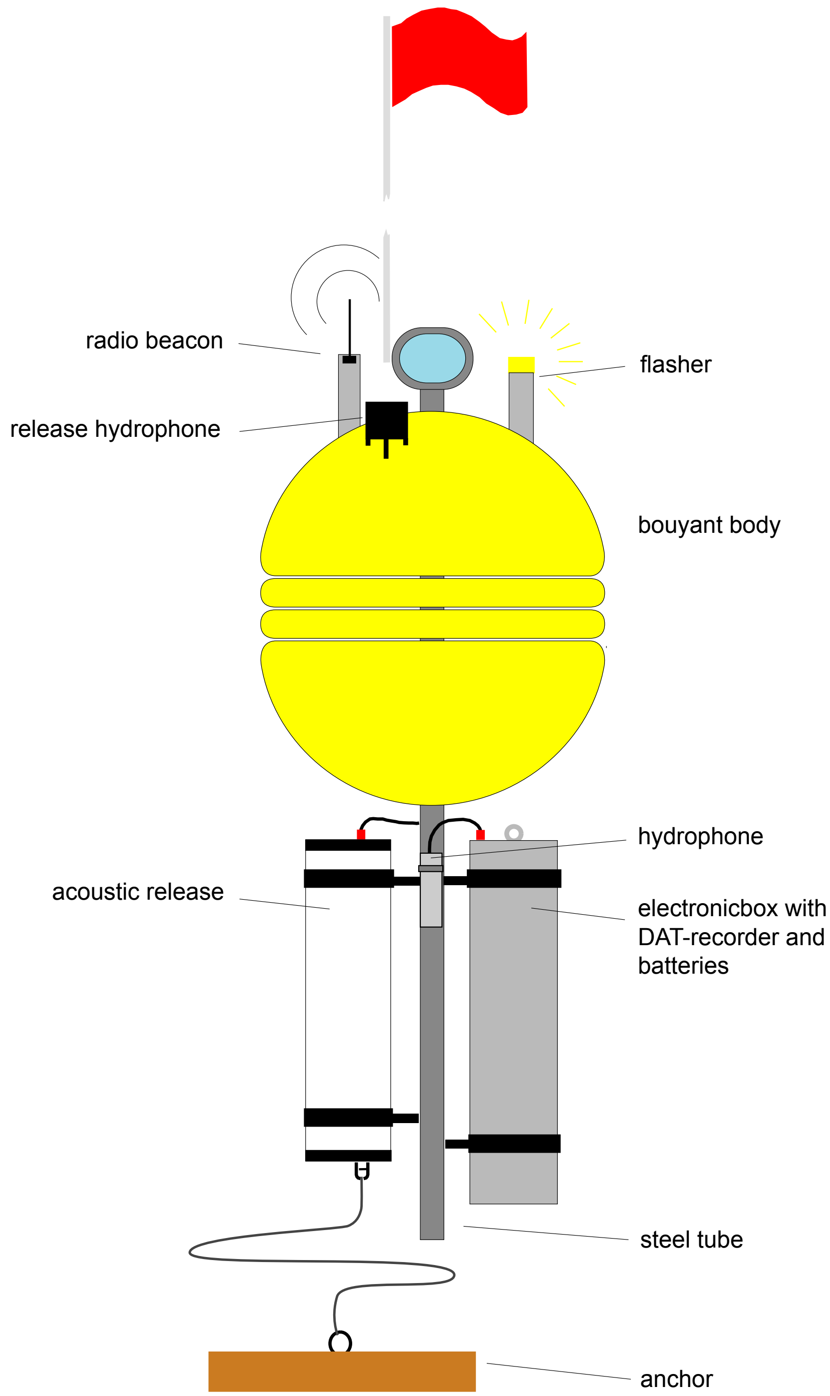

-84.84˚
-84.839˚
km
0
0.1
0.2
9.967˚
9.966˚
GPS Fixes at Anchor
Puntarenas, Costa Rica
24 May 2000
Time Periods (2 hour) of GPS Fixes
Blue Period 1
Aqua Period 2
Brown Period 3
Red Period 4
Pink Period 5
Green Period 6
Black Period 7
Gray Period 8

Figure 5



Design of the GEOMAR-OBH

GEOMAR

Figure 6

NicSeis OBH Locations

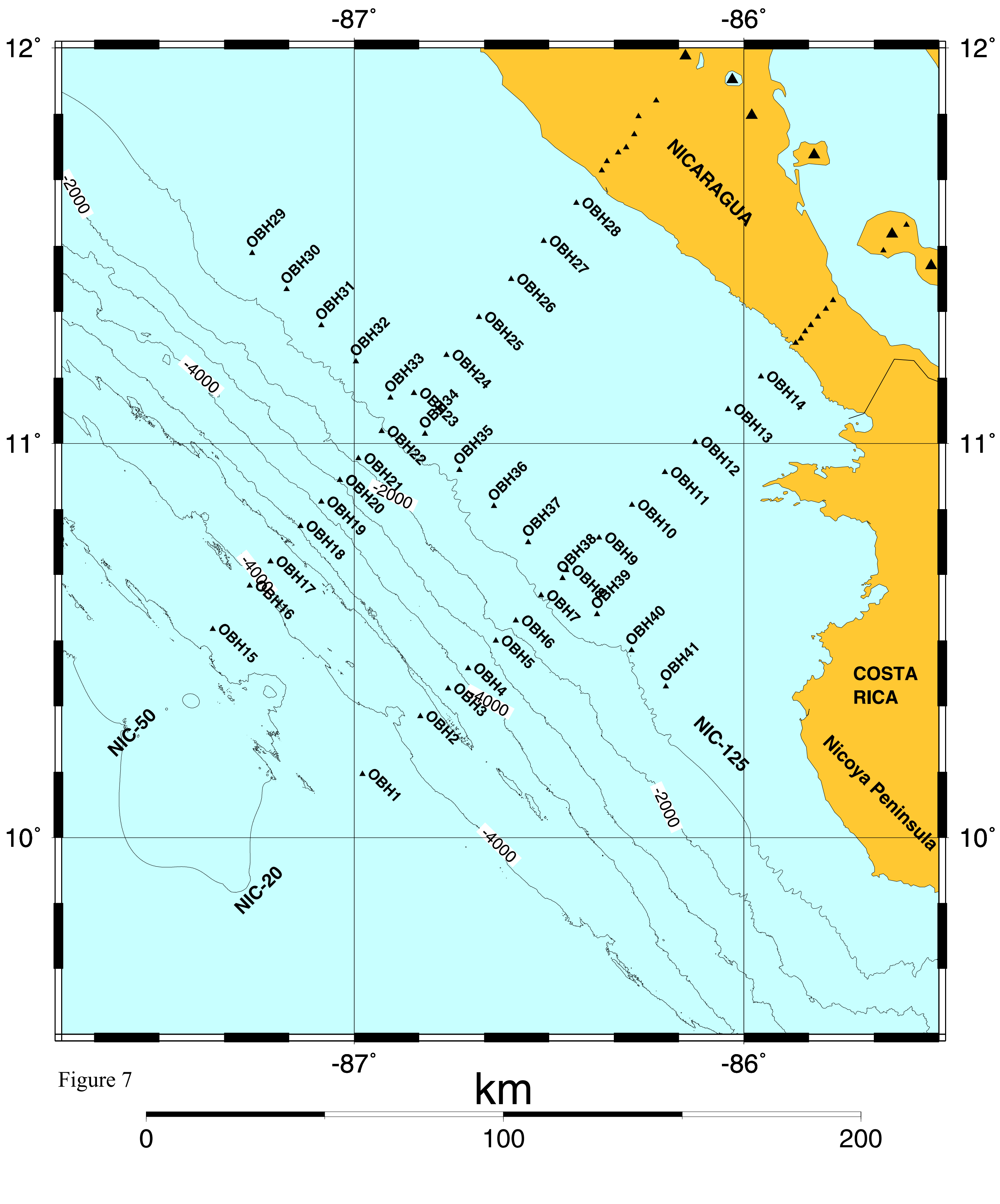


Figure 7

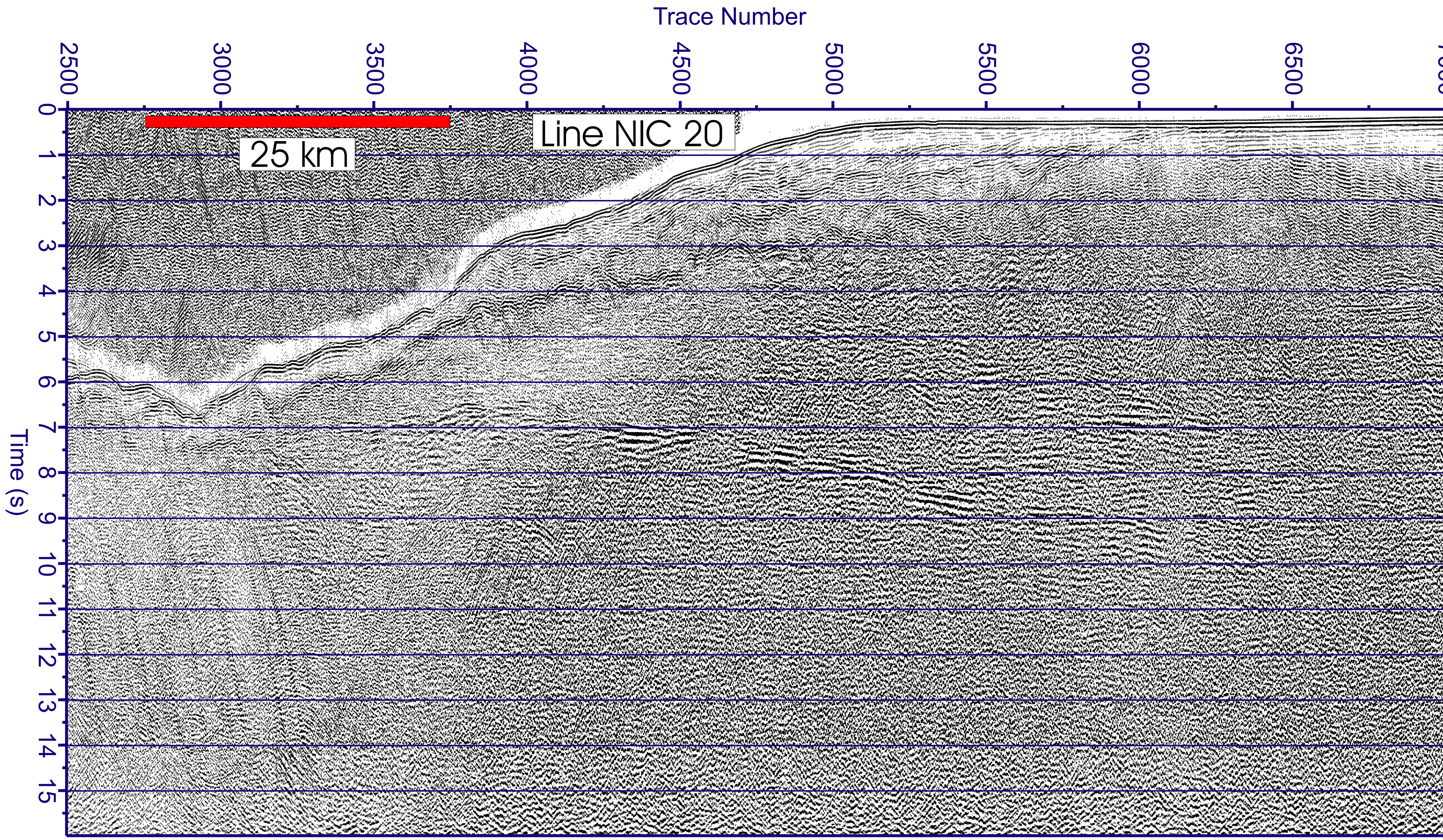

Trace Number
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
Line NIC 20
25 km
Time (s)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure 8

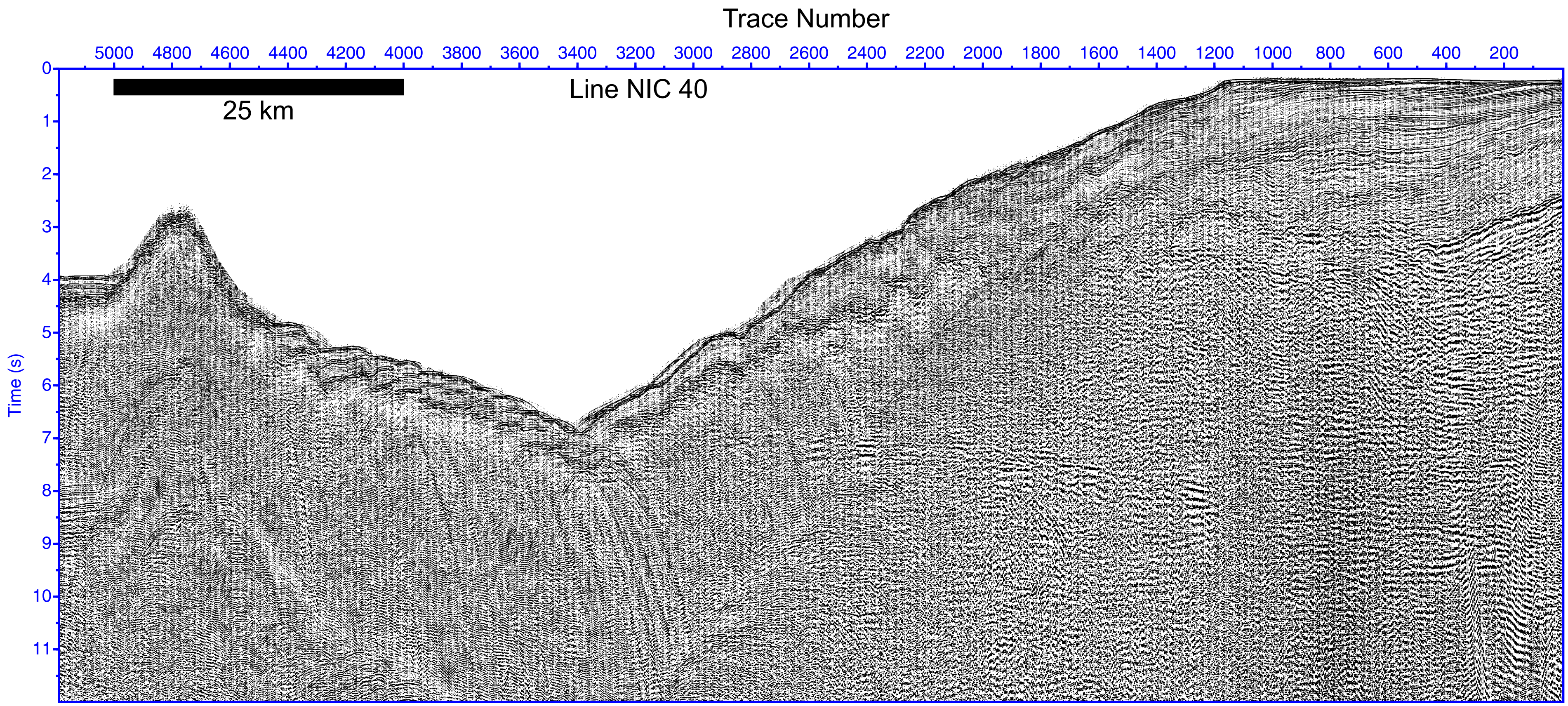
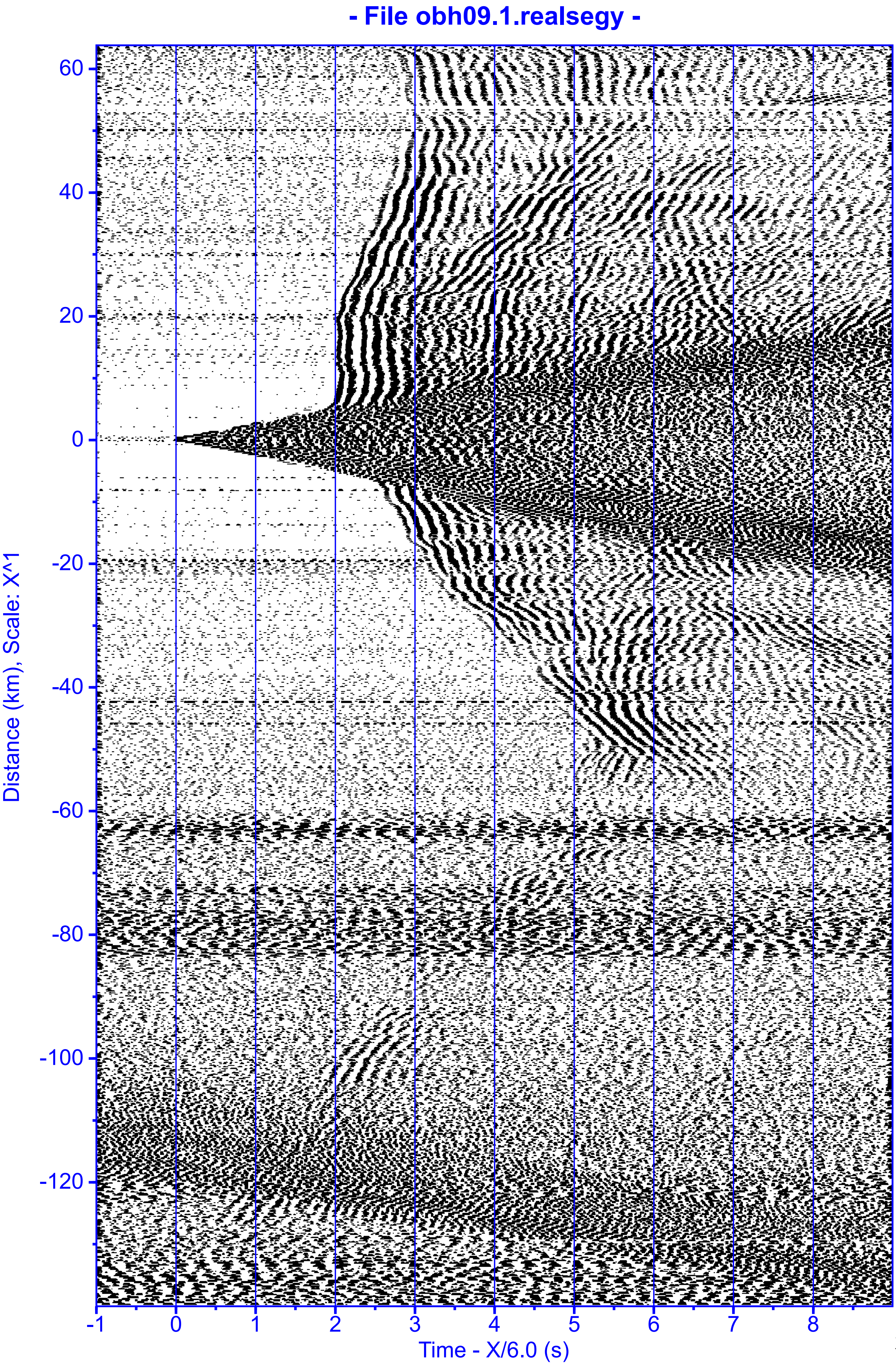

Trace Number
5000
4800
4600
4400
4200
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
Line NIC 40
25 km
Time (s)
0
1
2
3
4
5
6
7
8
9
10
11

Figure 9

Figure 10



- File obh09.1.realsegy -
Distance (km), Scale: X^1
Time - X/6.0 (s)
60
40
20
0
-20
-40
-60
-80
-100
-120
-1
0
1
2
3
4
5
6
7
8

Figure 11

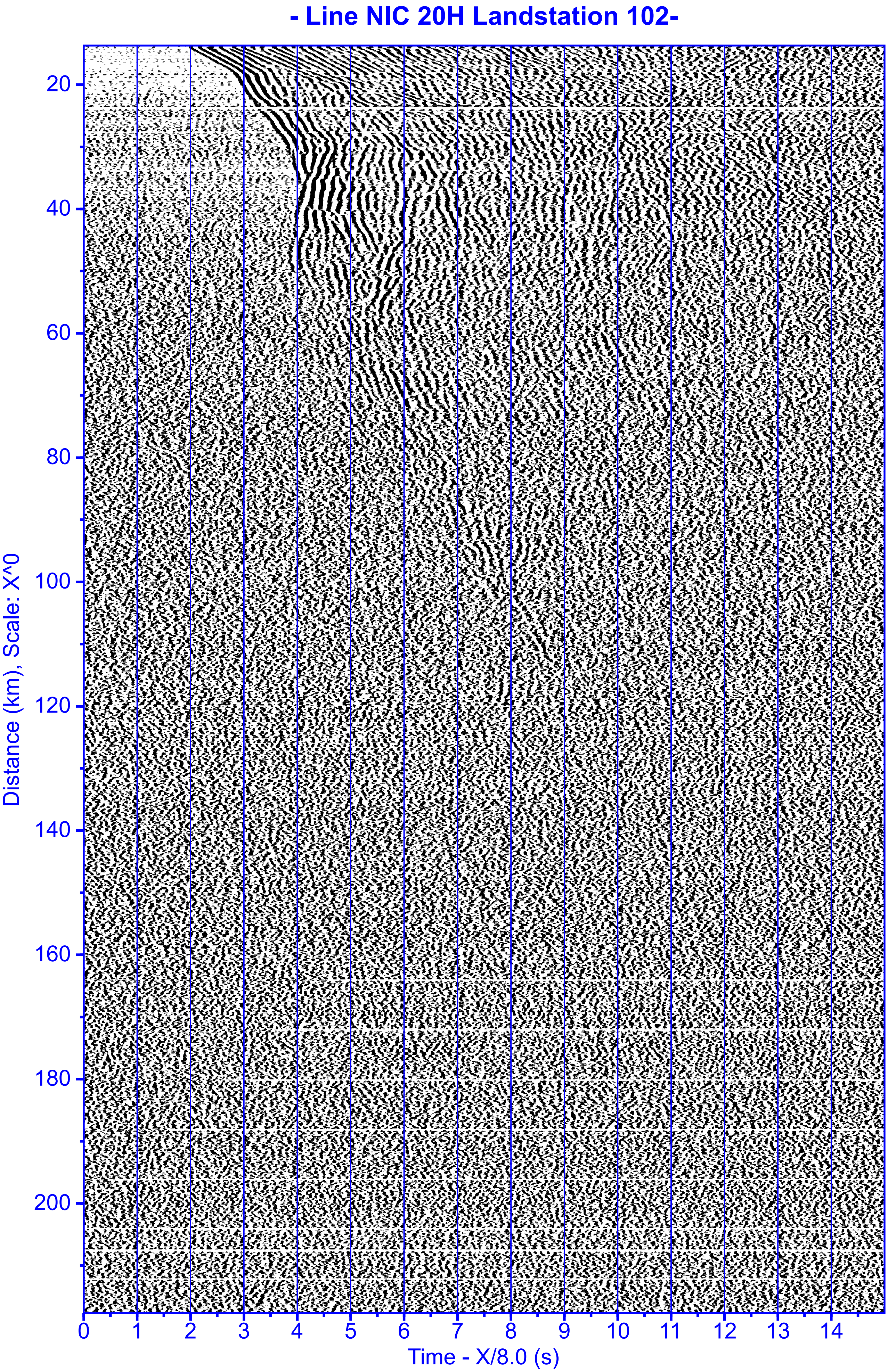
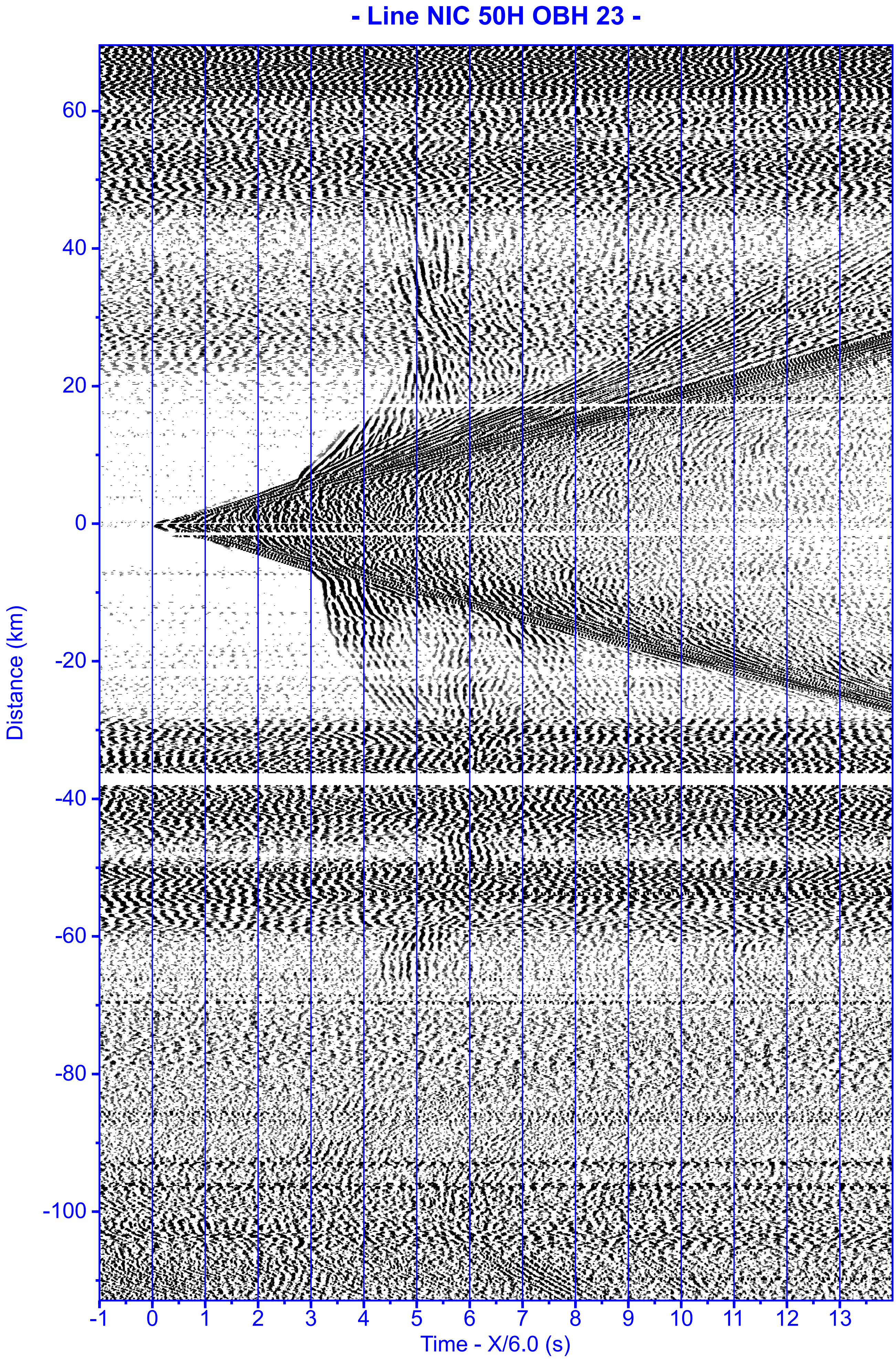

- Line NIC 20H Landstation 102-
Distance (km), Scale: X^0
20
40
60
80
100
120
140
160
180
200
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Time - X/8.0 (s)

Figure 12



- Line NIC 50H OBH 23 -
Distance (km)
60
40
20
0
-20
-40
-60
-80
-100
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Time - X/6.0 (s)

Figure 13

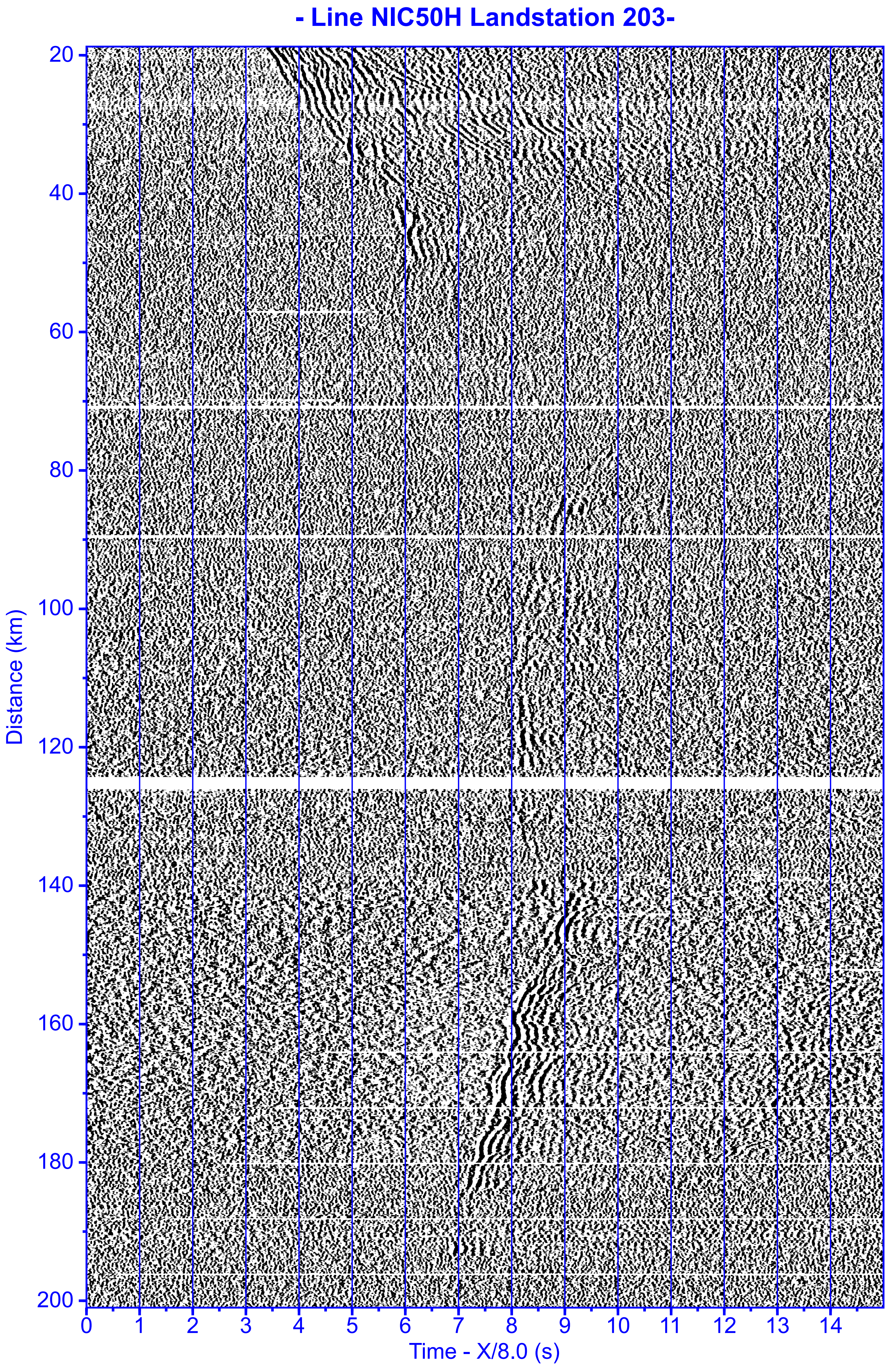

- Line NIC50H Landstation 203-
Distance (km)
20
40
60
80
100
120
140
160
180
200
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Time - X/8.0 (s)

Figure 14

Appendix 1

NicSeis Acquisition Line Summary

Line	Year	JDay/GMT	Latitude (North)	Longitude (West)	Shot Number	Tape Number	Ship Speed*	Shot Control**	Record Length	Comments
NIC20H	2000	150:21:33:42.190	11 10.7415	085 56.7831	000001	1	4.0	dist/125m	20	BOL
	2000	150:23:32			000113	3		time/60s	20	switch to time trigger--problem
	2000	152:00:47:58.158	09 53.4431	087 15.1127	001629	51				EOL
NIC20	2000	152:02:43:43.189	09 52.4799	087 16.0870	000001	50	4.86	dist/50m	16	BOL
	2000	152:04:06						time/20s		switch to time trigger--problem
	2000	153:01:51:30.164	11 11.8250	085 55.6675	004163	95				EOL
NIC15	2000	153:02:10:52.174	11 11.7208	085 54.3582	004218	96	4.86	time/20s	16	BOL
	2000	153:03:16:32.168	11 07.3995	085 51.2811	004415	98				EOL
NIC14	2000	153:03:42:45.164	11 05.6027	085 51.7113	000050	100	4.00	time/24s	20	BOL
	2000	153:09:06:45.159	10 50.4181	086 07.1828	000860	111				EOL
NIC10	2000	153:11:54:00.207	10 44.1193	085 58.8444	000001	112	4.86	time/20s	16	BOL
	2000	154:00:39:40.167	10 00.6485	086 43.4411	002298	137				EOL
NIC22	2000	154:04:15:57.207	10 06.6612	086 58.6769	000001	140	4.86	dist/50m	16	BOL
	2000	154:14:37:21.647	10 42.0613	086 22.8125	001847	158				EOL
NIC26	2000	154:15:32:25.193	10 44.1499	086 25.3768	000001	159	4.86	dist/50m	16	BOL
	2000	155:01:15:05.751	10 11.1967	086 58.7334	001720	177				EOL
NIC24	2000	155:01:56:28.220	10 09.7544	086 57.2546	000001	178	4.86	dist/50m	16	BOL
	2000	155:05:21			000616			time/20s		switch to time trigger--problem
	2000	155:10:49:22.255	10 40.3363	086 26.1502	001601	195				EOL
NIC28	2000	155:11:43:34.399	10 43.2563	086 27.7218	000001	196	4.86	time/20s	16	BOL
	2000	155:21:30:14.304	10 09.6656	087 01.8592	001761	215				EOL
NIC30	2000	155:23:24:17.439	10 13.4216	087 09.3628	000001	216	4.86	time/20s	16	BOL
	2000	156:14:31:17.609	11 06.8114	086 18.1941	002722	245				EOL
NIC31	2000	156:15:10:19.649	11 09.3037	086 19.4688	000001	246	4.86	time/20s	16	BOL
	2000	156:16:40:59.658	11 14.2392	086 25.0080	000273	250				EOL
NIC40	2000	156:17:52:24.668	11 11.4059	086 29.4927	000015	250	4.86	time/20s	16	BOL
	2000	157:08:29:24.404	10 19.1160	087 17.6070	002646	278				EOL
NIC50H	2000	160:13:30:48.204	11 36.3282	086 25.9331	000001	100	4.0	time/60s	20	BOL
	2000	161:13:45:47.687	10 21.1288	087 30.8676	001450	135				EOL

Appendix 1 -- continued

Line	Year	JDay/GMT	Latitude (North)	Longitude (West)	Shot Number	Tape Number	Ship Speed*	Shot Control**	Record Length	Comments
NIC50	2000	161:15:31:01.121	10 21.0988	087 30.9177	000092	151	4.86	time/20s	16	BOL
	2000	162:11:49:32.694	11 36.4409	086 25.8548	003716	190				EOL
NIC60A	2000	162:14:12:16.198	11 43.2103	086 33.5967	000030	192	4.0	time/24s	20	BOL
	2000	162:16:36:05.845	11 34.5925	086 41.1960	000413	197				EOL
Nic54	2000	163:23:34:31.170	10 38.8458	087 14.1948	000034	200	4.86	time/20s	16	BOL
	2000	164:06:53:11.346	11 05.6776	086 51.0609	001350	215				EOL
Nic56	2000	164:07:34:21.226	11 07.2273	086 52.6796	000023	217	4.86	time/20s	16	BOL
	2000	164:15:03:21.335	10 39.4159	087 16.5267	001370	231				EOL
Nic52	2000	164:16:41:27.255	10 37.9302	087 13.5775	001382	232	4.86	time/20s	16	BOL
	2000	165:02:12:47.281	11 13.2545	086 43.0351	003096	250				EOL
Nic52c	2000	165:02:32:47.253	11 14.8127	086 43.1865	003156	250	4.86	time/20s	16	BOL
	2000	165:04:37:27.421	11 22.0916	086 50.4708	003530	256				EOL
Nic60b	2000	165:05:00:38.208	11 22.0365	086 52.1440	000030	257	4.86	time/20s	16	BOL
	2000	165:18:30:38.275	10 32.1848	087 35.4184	002460	284				EOL
Nic70	2000	165:21:19:00.172	10 41.3205	087 45.8856	000030	290	4.86	time/20s	16	BOL
	2000	166:10:55:00.191	11 29.3020	086 59.5062	002478	317				EOL
Nic70c	2000	166:11:12:42.299	11 30.6686	086 59.5104	000006	317	4.86	time/20s	16	BOL
	2000	166:12:57:49.315	11 36.5597	087 05.6644	000318	322				EOL
Nic80	2000	167:21:41:00.206	10 43.7844	088 00.5344	000001	386	4.86	dist/50m	16s	BOL
	2000	168:14:31			003005	421	4.00		20s	Record 20s for deep reflections
	2000	168:19:09:19.122	11 55.7060	086 49.8628	003688	432				EOL
Nic80c	2000	168:19:22:05.047	11 56.4999	086 49.8131	000025	433	4.0	dist/50m	20s	BOL
	2000	169:01:19:54.220	12 17.6492	087 01.2642	000909	445				EOL
Nic84	2000	166:13:16:37.490	11 36.6864	087 07.0538	000030	323	4.86	dist/50m	16	BOL
	2000	166:22:51:01.952	11 02.9464	087 39.9642	001756	342				EOL
Nic86	2000	166:23:58:03.194	11 04.6981	087 41.3696	000001	345	4.86	dist/50m	16	BOL
	2000	167:07:07:27.422	11 29.8570	087 16.7305	001291	359				EOL
Nic82	2000	167:08:01:22.207	11 27.5081	087 14.4552	000001	360	4.86	dist/50m	16	BOL
	2000	167:20:49:26.240	10 42.1845	087 58.6453	002320	385				EOL

Appendix 1 -- continued

Line	Year	JDay/GMT	Latitude (North)	Longitude (West)	Shot Number	Tape Number	Ship Speed*	Shot Control**	Record Length	Comments
Nic90	2000	169:01:43:38.787	12 17.7759	087 02.6885	000020	446	4.0	dist/50m	20s	BOL
	2000	169:08:06:10.299	11 57.5178	087 18.2294	000953		4.86		16s	missed shots 947-952
	2000	169:19:47:23.358	11 13.4252	087 52.0889	002992	482				EOL
Nic90c	2000	169:20:05:00.960	11 13.3191	087 53.4140	003036	482	4.86	dist/50m	16s	BOL
	2000	170:00:14:11.778	11 24.6182	088 11.0032	003800	493				EOL
Nic100	2000	170:00:39:07.981	11 26.3781	088 11.5128	000040	494	4.86	dist/50m	16s	BOL
	2000	170:13:12:15.824	12 13.0832	087 38.5145	2110	2110	4.0		20s	Record longer for deep events
	2000	170:19:30:40.339	12 33.8216	087 23.9675	003038	2129				EOL (gap 13:04-13:10 @chng)
Nic100c	2000	170:20:36:01.206	12 36.8177	087 27.4383	000001	2140	4.0	dist/50m	16s	BOL
	2000	171:00:06:18.708	12 45.4632	087 42.2551	000625	2146				EOL
Nic110	2000	171:00:24:34.197	12 44.9624	087 43.4681	000001	2147	4.0	dist/50m	20s	BOL
	2000	171:16:27:57.122	11 44.6794	088 15.5764	002508	2177				EOL?-Comp. failed, end early
	2000	171:16:36	11 44.1211	088 15.8690	002531	2178			20s	Not clear when line ended
Nic110x	2000	171:19:53:00.191	11 45.0214	088 15.4207	000001	2180	4.86	dist/50m	16s	BOL- Circle back, resume 110
	2000	172:00:34:54.279	11 24.9128	088 26.0495	000837	2189				EOL
NIC125H	2000	173:10:19:01.202	10 18.4506	086 07.6054	000001	2200	4.0	dist/125m	16s	BOL Shoot to OBHs + MCS
	2000	174:10:22:21.943	11 32.8746	087 19.6067	001520	2231				EOL
NIC125C	2000	174:10:40:48.682	11 32.8281	087 21.0169	001542	2232	4.86	dist/50m	16s	BOL
	2000	174:12:10:00.319	11 27.6136	087 26.1823	001811	2234				EOL
NIC125D	2000	174:12:26:48.212	11 26.6318	087 27.1485	000001	2235	4.86	dist/50m	16s	BOL
	2000	174:14:32:19.631	11 19.3816	087 34.2807	000373	2239				EOL
NIC115	2000	174:14:57:43.802	11 17.7651	087 34.5848	000040	2240	4.86	dist/50m	16s	BOL
	2000	175:15:06:48.660	09 59.5404	086 20.4043	004003	2285				EOL

* Ship speed is the target "speed made good" or speed over ground.
** Shot control indicates whether the shots were triggered on (randomized) time or distance and at what interval. On the MCS lines we attempted to shoot every 50 m, whether triggered by time or distance. For the OBH lines (20H, 50H, 125H) we attempted to shoot every 125 m, while moving at about 4 kt. This results in shots about every 60 s and reduces noise from previous shots.

Appendix 2

Seismic reflection data field tape description

NIC20H

Tape(reel)	Shots	JDay	Start Time	Rec. Length
1	3-74	150	22:41	20720
2	75-102	150	22:55	20720
3	103-175	150	23:21	20720
4	176-199	151	24:37	20720
5	200-270	151	01:01	20720
6	272-293	151	02:11	20720
7	294-365	151	02:33	20720
8	366-387	151	03:45	20720
9	388-460	151	04:09	20720
10	460-527	151	05:19	20720
11	528-594	151	06:26	20720
12	604-627	151	07:45	20720
13	628-699	151	08:07	20720
14	700-722	151	09:19	20720
15	723-795	151	09:41	20720
16	795-817	151	10:54	20720
17	819-890	151	11:17	20720
18	891-912	151	12:31	20720
19	913-985	151	12:51	20720
20	986-1009	151	14:04	20720
21	1010-1081	151	14:28	20720
22	1082-1107	151	15:42	20720
23	1108-1179	151	16:07	20720
24	1180-1203	151	17:20	20720
25	1204-1275	151	17:42	20720
26	1276-1299	151	18:58	20720
27	1300-1370	151	19:19	20720
28	1371-1397	151	20:31	20720
29	1398-1464	151	20:53	20720
30	1465-1487	151	22:04	20720
31	1488-1559	151	22:29	20720

NIC20

Tape(reel)	Shots	JDay	Start Time	Rec. Length
50	1-91	152	02:43:50	16624
51	92-182	152	03:14:05	16624
52	183-273	152	03:46	16624
53	274-364	152	04:15	16624
54	365-455	152	04:46	16624
55	456-546	152	05:15	16624
56	547-637	152	05:46	16624
57	638-728	152	06:16	16624
58	729-819	152	06:46	16624
59	820-910	152	07:17	16624
60	911-1001	152	07:47	16624
61	1002-1092	152	08:17	16624
62	1093-1183	152	08:48	16624
63	1184-1274	152	09:18	16624
64	1275-1365	152	09:48	16624
65	1366-1456	152	10:19	16624
66	1457-1547	152	10:50	16624
67	1548-1638	152	11:19	16624
68	1639-1729	152	11:50	16624
69	1730-1820	152	12:21	16624
70	1821-1911	152	12:52	16624
71	1912-2002	152	13:21	16624
72	2003-2093	152	13:52	16624
73	2094-2184	152	14:22	16624
74	2185-2275	152	14:52	16624
75	2276-2366	152	15:23	16624
76	2367-2457	152	15:53	16624
77	2458-2548	152	16:23	16624
78	2549-2639	152	16:53	16624
79	2640-2730	152	17:24	16624
80	2731-2821	152	17:54	16624
81	2822-2912	152	18:26	16624
82	2913-3003	152	18:54	16624
83	3004-3094	152	19:25	16624
84	3095-3185	152	19:55	16624
85	3186-3276	152	20:27	16624
86	3277-3367	152	20:57	16624
87	3368-3458	152	21:26	16624
88	3459-3549	152	21:57	16624
89	3550-3640	152	22:27	16624
90	3641-3731	152	22:57	16624
91	3732-3822	152	23:28	16624
92	3823-3913	153	23:58	16624
93	3914-4004	153	00:28	16624
94	4005-4095	153	00:58	16624
95	4096-4176	153	01:29	16624

NIC15

Tape(reel)	Shots	JDay	Start Time	Rec. Length
96	4177-4268	153	01:53	16624
97	4269-4359	153	02:28	16624
98	4360-4416	153	02:58	16624

NIC14

Tape(reel)	Shots	JDay	Start Time	Rec. Length
100	1-72	153	03:24	20240
101	73-144	153	03:51	20240
102	145-216	153	04:21	20240
103	217-288	153	04:50	20240
104	289-360	153	05:18	20240
105	361-432	153	05:47	20240

NIC14-continued

Tape(reel)	Shots	JDay	Start Time	Rec. Length
106	433-504	153	06:16	20240
107	505-576	153	06:44	20240
108	577-648	153	07:13	20240
109	649-720	153	07:42	20240
110	721-792	153	08:11	20240
111	793-859	153	08:40	20240

NIC10

Tape(reel)	Shots	JDay	Start Time	Rec. Length
112	1-91	153	11:54	16624
113	92-182	153	12:24	16624
114	183-273	153	1:55	16624
115	274-364	153	13:25	16624
116	365-455	153	13:55	16624
117	456-546	153	14:26	16624
118	547-637	153	14:56	16624
119	638-728	153	15:27	16624
120	729-816	153	15:56	16624
121	817-910	153	16:26	16624
122	911-1001	153	16:57	16624
123	1002-1092	153	17:28	16624
124	1093-1183	153	17:59	16624
125	1184-1274	153	18:28	16624
126	1275-1365	153	18:58	16624
127	1366-1456	153	19:29	16624
128	1457-1547	153	19:59	16624
129	1548-1638	153	20:29	16624
130	1639-1729	153	20:59	16624
131	1730-1820	153	21:30	16624
132	1821-1911	153	22:00	16624
133	1912-2002	153	22:31	16624
134	2003-2093	153	23:01	16624
135	2094-2184	153	23:31	16624
136	2185-2275	154	00:02	16624
137	2276-2298	154	00:32	16624
*138				
*139				

NIC22

Tape(reel)	Shots	JDay	Start Time	Rec. Length
140	1-91	154	04:31	16624
141	92-182	154	04:46	16624
142	183-197	154	05:17	16624
143	437-527	154	06:23	16624
144	528-618	154	07:13	16624
145	619-708	154	07:44	16624
146	709-800	154	08:15	16624
147	801-891	154	08:46	16624
148	892-982	154	09:17	16624
149	983-1073	154	09:47	16624
150	1074-1164	154	10:17	16624
151	1165-1255	154	10:48	16624
152	1256-1346	154	11:20	16624
153	1347-1438	154	11:52	16624
154	1439-1529	154	12:23	16624
155	1530-1620	154	12:53	16624
156	1621-1711	154	13:23	16624
157	1712-1802	154	13:51	16624
158	1803-1876	154	14:22	16624

NIC26

Tape(reel)	Shots	JDay	Start Time	Rec. Length
159	1-91	154	15:32	16624
160	92-184	154	16:06	16624
161	185-275	154	16:39	16624
162	276-366	154	17:10	16624
163	367-457	154	17:40	16624
164	458-548	154	18:10	16624
165	549-639	154	18:41	16624
166	640-742	154	19:12	16624
167	743-833	154	19:45	16624
168	834-924	154	20:17	16624
169	924-1015	154	20:48	16624
170	1016-1106	154	21:18	16624
171	1107-1197	154	21:47	16624
172	1198-1288	154	22:18	16624
173	1289-1379	154	22:49	16624
174	1380-1472	154	23:20	16624
175	1473-1563	155	23:53	16624
176	1564-1654	155	00:24	16624
177	1655-1720	155	00:53	16624

NIC24

Tape(reel)	Shots	JDay	Start Time	Rec. Length
178	1-91	155	02:00	16624
179	92-182	155	02:26	16624
180	183-273	155	02:57	16624
181	274-364	155	03:27	16624
182	365-455	155	03:57	16624
183	456-546	155	04:27	16624
184	547-646	155	04:58	16624
185	647-737	155	05:31	16624
186	738-828	155	06:01	16624
187	829-919	155	06:32	16624
188	920-1010	155	07:02	16624
189	1011-1101	155	07:32	16624
190	1102-1192	155	08:03	16624
191	1193-1283	155	08:33	16624
192	1284-1374	155	09:03	16624
193	1375-1465	155	09:34	16624
194	1466-1556	155	10:04	16624
195	1557-1601	155	10:34	16624

NIC28

Tape(reel)	Shots	JDay	Start Time	Rec. Length
196	1-91	155	11:43	16624
197	92-182	155	12:14	16624
198	183-273	155	12:44	16624
199	274-364	155	13:15	16624
200	365-455	155	13:44	16624
201	456-546	155	14:15	16624
202	547-637	155	14:45	16624
203	638-728	155	15:15	16624
204	729-819	155	15:46	16624
205	820-910	155	16:16	16624
206	911-1001	155	16:47	16624
207	1002-1092	155	17:17	16624
208	1093-1183	155	17:47	16624
209	1184-1274	155	18:19	16624
210	1275-1365	155	18:48	16624
211	1366-1456	155	19:18	16624
212	1457-1547	155	19:50	16624
213	1548-1638	155	20:20	16624
214	1639-1729	155	20:49	16624
215	1730-1761	155	21:20	16624

NIC30

Tape(reel)	Shots	JDay	Start Time	Rec. Length
216	1-91	155	23:24	16624
217	92-182	155	23:54	16624
218	183-273	156	00:25	16624
219	274-364	156	00:55	16624
220	365-447	156	01:26	16624
221	448-538	156	01:54	16624
222	539-629	156	02:24	16624
223	630-720	156	02:54	16624
224	721-811	156	03:24	16624
225	812-902	156	03:55	16624
226	903-993	156	04:25	16624
227	994-1084	156	04:55	16624
228	1085-1175	156	05:26	16624
229	1176-1266	156	05:56	16624
230	1267-1357	156	06:26	16624
231	1358-1448	156	06:56	16624
232	1449-1539	156	07:27	16624
233	1540-1630	156	07:57	16624
234	1631-1721	156	08:27	16624
235	1722-1812	156	08:57	16624
236	1813-1903	156	09:28	16624
237	1904-1994	156	09:59	16624
238	1995-2085	156	10:28	16624
239	2086-2176	156	10:59	16624
240	2177-2267	156	11:29	16624
241	2268-2358	156	12:00	16624
242	2365-2455	156	12:32	16624
243	2456-2546	156	13:02	16624
244	2547-2637	156	13:33	16624
245	2638-2722	156	14:03	16624

NIC31

Tape(reel)	Shots	JDay	Start Time	Rec. Length
246	7-91	156	15:10	16624
247	92-182	156	15:40	16624
248	183-273	156	16:11	16624
249	274-275	156	16:41	16624

NIC40

Tape(reel)	Shots	JDay	Start Time	Rec. Length
250	0-100	156	17:51	16624
251	101-191	156	18:21	16624
252	192-282	156	18:52	16624
253	283-373	156	19:23	16624
254	374-464	156	19:52	16624
255	465-555	156	20:23	16624
256	556-646	156	20:52	16624
257	647-737	156	21:23	16624
258	738-828	156	21:54	16624
259	829-919	156	22:23	16624
260	920-1010	156	22:53	16624
261	1011-1101	156	23:24	16624
262	1102-1192	156	23:54	16624
263	1193-1283	157	00:25	16624
264	1284-1374	157	00:55	16624
265	1375-1465	157	01:26	16624
266	1466-1556	157	01:56	16624
267	1557-1647	157	02:26	16624
268	1648-1738	157	02:57	16624
269	1739-1829	157	03:27	16624
270	1830-1920	157	03:57	16624
271	1921-2011	157	04:27	16624
272	2012-2102	157	04:58	16624
273	2103-2193	157	05:28	16624
274	2194-2284	157	05:58	16624
275	2285-2375	157	06:29	16624
276	2376-2466	157	06:59	16624
277	2467-2557	157	07:29	16624
278	2558-2646	157	08:00	16624

NIC50H

Tape(reel)	Shots	JDay	Start Time	Rec. Length
100	1-21	160	13:30	20720
101	22-93	160	1355	20720
102	94-114	160	15:04	20720
103	115-186	160	15:24	20720
104	187-207	160	16:38	20720
105	208-279	160	16:57	20720
106	280-300	160	18:09	20720
107	301-372	160	18:34	20720
108	373-393	160	19:43	20720
109	394-466	160	20:04	20720

NIC50H-continued

Tape(reel)	Shots	JDay	Start Time	Rec. Length
*110	**NO TAPE**			20720
111	470-541	160	21:23	20720
112	542-568	160	22:35	20720
113	569-640	160	23:05	20720
*114	**NO TAPE**			20720
115	644-715	161	00:15	20720
116	716-736	161	01:31	20720
117	737-808	161	01:51	20720
*118	**NO TAPE**			20720
*119	**NO TAPE**	161	03:04	20720
120	816-823	161	03:10	20720
121	825-828	161	04:54	20720
122	918-937	161	05:00	20720
123	939-1010	161	05:15	20720
*124	**NO TAPE**			20720
125	1014-1085	161	06:27	20720
126	1086-1105	161	07:41	20720
127	1106-1177	161	08:01	20720
*128	**NO TAPE**			20720
129	1181-1199	161	09:17	20720
130	1200-1271	161	09:35	20720
131	1272-1291	161	10:47	20720
132	1292-1363	161	11:07	20720
*133	**NO TAPE**			20720
134	1367-1438	161	12:18	20720
135	1439-1450	161	12:34	20720
*136-149	skipped			20720

NIC50

Tape(reel)	Shots	JDay	Start Time	Rec. Length
150	1-91	161	15:01	16624
151	92-182	161	15:30	16624
152	183-273	161	16:02	16624
153	274-364	161	16:32	16624
154	365-455	161	17:03	16624
155	456-546	161	17:34	16624
156	547-637	161	18:04	16624
157	638-728	161	18:34	16624
158	729-819	161	19:04	16624
159	820-910	161	19:34	16624
160	911-1001	161	20:05	16624
161	1002-1092	161	20:35	16624
162	1093-1183	161	21:05	16624
163	1184-1274	161	21:36	16624
164	1275-1365	161	22:06	16624
165	1366-1456	161	22:36	16624
166	1457-1547	161	23:06	16624
167	1548-1639	161	23:40	16624
168	1640-1730	162	00:12	16624
169	1731-1821	162	00:43	16624
170	1822-1912	162	01:12	16624
171	1913-2003	162	01:47	16624
172	2004-2094	162	02:13	16624
173	2095-2185	162	02:43	16624
174	2186-2276	162	03:13	16624
175	2277-2368	162	03:43	16624
176	2369-2459	162	04:18	16624
177	2460-2550	162	04:48	16624
178	2551-2641	162	05:18	16624
179	2642-2732	162	05:48	16624
180	2733-2824	162	06:18	16624
181	2825-2915	162	06:52	16624
182	2916-3006	162	07:22	16624
183	3007-3097	162	07:53	16624
184	3098-3188	162	08:23	16624
185	3189-3280	162	08:53	16624
186	3281-3372	162	09:24	16624
187	3373-3463	162	09:55	16624
188	3464-3554	162	10:25	16624
189	3555-3645	162	10:55	16624
190	3646-3732	162	11:26	16624

NIC60A

Tape(reel)	Shots	JDay	Start Time	Rec. Length
192	9-80	162	14:00	20720
193	81-152	162	14:33	20720
194	153-224	162	15:02	20720
195	225-299	162	15:31	20720
196	300-390	162	15:59	20720
197	391-413	162	16:29	20720

NIC54

Tape(reel)	Shots	JDay	Start Time	Rec. Length
200	1-91	163	23:23	16624
201	92-182	163	23:54	16624
202	190-273	164	00:24	16624
203	274-364	164	00:55	16624
204	365-455	164	01:25	16624
205	456-546	164	01:55	16624
206	547-637	164	02:26	16624
207	638-728	164	02:56	16624
208	729-819	164	03:26	16624
209	820-879	164	03:57	16624
210	880-970	164	04:16	16624
211	971-1061	164	04:47	16624
212	1062-1152	164	05:17	16624
213	1153-1243	164	05:48	16624
214	1244-1335	164	06:17	16624
215	1350-1425	164	06:54	16624

NIC56

Tape(reel)	Shots	JDay	Start Time	Rec. Length
217	1-100	164	07:30	16624
218	101-191	164	08:00	16624
219	192-282	164	08:31	16624

NIC56-continued

Tape(reel)	Shots	JDay	Start Time	Rec. Length
220	283-373	164	09:01	16624
221	374-464	164	09:31	16624
222	465-555	164	10:01	16624
223	556-646	164	10:31	16624
224	647-737	164	11:02	16624
225	738-828	164	11:32	16624
226	829-919	164	12:03	16624
227	920-1010	164	12:33	16624
228	1011-1101	164	13:03	16624
229	1102-1192	164	13:34	16624
230	1193-1283	164	14:04	16624
231	1284-1368	164	14:35	16624

NIC52

Tape(reel)	Shots	JDay	Start Time	Rec. Length
232	1372-1462	164	16:41	16624
233	1463-1553	164	17:09	16624
234	1554-1644	164	17:39	16624
235	1645-1735	164	18:09	16624
236	1736-1826	164	18:39	16624
237	1827-1917	164	19:09	16624
238	1918-2008	164	19:40	16624
239	2009-2099	164	20:11	16624
240	2100-2190	164	20:41	16624
241	2191-2281	164	21:11	16624
242	2282-2375	164	21:41	16624
243	2373-2463	164	22:12	16624
244	2464-2554	164	22:44	16624
245	2555-2645	164	23:13	16624
246	2646-2736	164	23:42	16624
247	2737-2827	165	00:14	16624
248	2828-2918	165	00:43	16624
249	2919-3009	165	01:14	16624

NIC52C

Tape(reel)	Shots	JDay	Start Time	Rec. Length
250	3010-3100	165	01:44	16624
251	3101-3191	165	02:14	16624
252	3192-3282	165	02:45	16624
253	3283-3373	165	03:15	16624
254	3374-3464	165	03:45	16624
255	3465-3555	165	04:16	16624
256	3556-3564	165	04:46	16624

NIC60B

Tape(reel)	Shots	JDay	Start Time	Rec. Length
257	1-91	165	04:53	16624
258	92-182	165	05:22	16624
259	183-273	165	05:52	16624
260	274-364	165	06:22	16624
261	365-455	165	06:52	16624
262	456-546	165	07:22	16624
263	547-637	165	07:53	16624
264	638-728	165	08:23	16624
265	729-819	165	08:53	16624
266	820-910	165	09:24	16624
267	911-1001	165	09:54	16624
268	1002-1092	165	10:24	16624
269	1093-1183	165	10:55	16624
270	11884-1274	165	11:25	16624
271	1275-1365	165	11:55	16624
272	1366-1456	165	12:26	16624
273	1457-1547	165	12:56	16624
274	1548-1638	165	13:26	16624
275	1639-1729	165	13:55	16624
276	1730-1820	165	14:27	16624
277	1821-1911	165	14:58	16624
278	1912-2002	165	15:28	16624
279	2003-2093	165	15:58	16624
280	2094-2184	165	16:28	16624
281	2185-2275	165	16:59	16624
282	2276-2366	165	17:29	16624
283	2367-2457	165	17:59	16624
284	2458-2487	165	18:30	16624
285	1-91	165	18:43	16624
286	92-182	165	19:13	16624
287	183-273	165	19:43	16624
288	274-364	165	20:14	16624
289	365-422	165	20:44	16624

NIC70

Tape(reel)	Shots	JDay	Start Time	Rec. Length
290	1-91	165	21:10	16624
291	92-182	165	21:39	16624
292	183-273	165	22:10	16624
293	274-364	165	22:40	16624
294	365-455	165	23:10	16624
295	456-546	165	23:40	16624
296	547-637	166	00:11	16624
297	638-728	166	00:42	16624
298	729-819	166	01:12	16624
299	820-910	166	01:42	16624
300	911-1001	166	02:13	16624
301	1002-1092	166	02:43	16624
302	1093-1183	166	03:13	16624
303	1184-1274	166	03:44	16624
304	1275-1365	166	04:14	16624
305	1366-1456	166	04:44	16624
306	1457-1547	166	05:14	16624
307	1548-1638	166	05:45	16624
308	1639-1729	166	06:15	16624
309	1730-1820	166	06:45	16624
310	1821-1911	166	07:16	16624
311	1912-2002	166	07:46	16624

NIC70-continued

Tape(reel)	Shots	JDay	Start Time	Rec. Length
312	2003-2093	166	08:16	16624
313	2094-2184	166	08:47	16624
314	2185-2275	166	09:17	16624
315	2276-2366	166	09:47	16624
316	2367-2457	166	10:18	16624
317	2458-2490	166	10:48	16624

NIC70C

Tape(reel)	Shots	JDay	Start Time	Rec. Length
319	1-92	166	11:11	16624
320	93-183	166	11:41	16624
321	184-274	166	12:12	16624
322	275-319	166	12:43	16624

NIC84

Tape(reel)	Shots	JDay	Start Time	Rec. Length
323	1-92	166	13:06	16624
324	93-184	166	13:37	16624
325	185-274	166	14:09	16624
326	275-366	166	14:38	16624
327	367-457	166	15:08	16624
328	458-549	166	15:38	16624
329	550-639	166	16:10	16624
330	640-732	166	16:40	16624
331	733-823	166	17:09	16624
332	824-914	166	17:39	16624
333	915-1005	166	18:10	16624
334	1006-1096	166	18:40	16624
335	1097-1187	166	19:11	16624
336	1188-1278	166	19:41	16624
337	1279-1369	166	20:11	16624
338	1370-1460	166	20:42	16624
339	1461-1551	166	21:12	16624
340	1552-1642	166	21:43	16624
341	1643-1734	166	22:15	16624
342	1735-1756	166	22:45	16624

NIC86

Tape(reel)	Shots	JDay	Start Time	Rec. Length
343	1-91	166	22:57	16624
344	92-97	166	23:26	16624
345	1-91	166	23:58	16624
346	92-182	167	00:29	16624
347	183-273	167	01:00	16624
348	274-364	167	01:31	16624
349	365-455	167	02:01	16624
350	456-546	167	02:31	16624
351	547-637	167	03:01	16624
352	638-728	167	03:31	16624
353	729-819	167	04:01	16624
354	820-910	167	04:31	16624
355	911-1001	167	05:02	16624
356	1002-1092	167	05:32	16624
357	1093-1183	167	06:03	16624
358	1184-1274	167	06:31	16624
359	1275-1291	167	07:02	16624

NIC82

Tape(reel)	Shots	JDay	Start Time	Rec. Length
360	1-91	167	08:01	16624
361	92-182	167	08:32	16624
362	183-273	167	09:02	16624
363	274-364	167	09:32	16624
364	365-455	167	10:02	16624
365	456-546	167	10:32	16624
366	547-637	167	11:02	16624
367	638-728	167	11:32	16624
368	729-819	167	12:02	16624
369	820-910	167	12:32	16624
370	911-1001	167	13:02	16624
371	1002-1092	167	13:30	16624
372	1093-1151	167	14:00	16624
373	1152-1249	167	14:19	16624
374	1250-1340	167	14:53	16624
375	1341-1431	167	15:23	16624
376	1432-1522	167	15:53	16624
377	1523-1613	167	16:24	16624
378	1614-1704	167	16:53	16624
379	1705-1795	167	17:23	16624
380	1796-1886	167	17:53	16624
381	1887-1977	167	18:24	16624
382	1978-2068	167	18:55	16624
383	2069-2159	167	19:25	16624
384	2160-2251	167	19:56	16624
385	2252-2320	167	20:27	16624

NIC80

Tape(reel)	Shots	JDay	Start Time	Rec. Length
386	1-91	167	21:41	16624
387	92-182	167	22:16	16624
388	183-273	167	22:52	16624
*389	**NO TAPE**			16624
390	280-370	167	23:22	16624
391	371-461	168	23:54	16624
392	462-552	168	00:24	16624
393	553-643	168	00:54	16624
394	644-734	168	01:24	16624
395	735-825	168	01:55	16624
396	826-916	168	02:26	16624
397	917-1007	168	02:56	16624
398	1008-1098	168	03:26	16624
399	1099-1189	168	03:56	16624
400	1190-1280	168	04:27	16624

NIC80-continued

Tape(reel)	Shots	JDay	Start Time	Rec. Length
401	1281-1371	168	04:56	16624
402	1372-1462	168	05:27	16624
403	1463-1553	168	05:57	16624
404	1554-1644	168	06:27	16624
405	1645-1735	168	06:57	16624
406	1736-1826	168	07:27	16624
407	1827-1917	168	07:58	16624
408	1918-2008	168	08:28	16624
409	2009-2099	168	08:58	16624
410	2100-2190	168	09:29	16624
411	2191-2281	168	09:59	16624
412	2282-2372	168	10:29	16624
*413	**NO TAPE**			16624
414	2380-2470	168	11:02	16624
415	2471-2561	168	11:32	16624
416	2562-2652	168	12:03	16624
417	2653-2643	168	12:32	16624
418	2644-2834	168	13:02	16624
419	2835-2925	168	13:31	16624
420	2926-3003	168	14:01	16624
421	3005-3005	168	14:31	20720
422	3006-3077	168	14:34	20720
423	3078-3149	168	15:00	20720
424	3150-3150	168	15:29	20720
425	3157-3228	168	15:30	20720
426	3229-3300	168	16:01	20720
427	3301-3372	168	16:31	20720
428	3373-3444	168	16:59	20720
429	3445-3516	168	17:29	20720
430	3517-3588	168	17:58	20720
431	3589-3660	168	18:28	20720
432	3661-3691	168	18:58	20720

NIC80C

Tape(reel)	Shots	JDay	Start Time	Rec. Length
433	1-72	168	19:12	20720
434	73-144	168	19:41	20720
435	145-216	168	20:11	20720
436	217-288	168	20:41	20720
437	289-360	168	21:09	20720
438	361-432	168	21:38	20720
439	433-504	168	22:08	20720
440	505-576	168	22:36	20720
441	577-648	168	23:06	20720
442	649-720	168	23:34	20720
443	721-792	169	00:04	20720
444	793-864	169	00:33	20720
445	865-936	169	01:02	20720

NIC90

Tape(reel)	Shots	JDay	Start Time	Rec. Length
446	1-74	169	01:36	20720
447	75-151	169	02:00	20720
448	152-223	169	02:37	20720
449	224-295	169	03:06	20720
450	296-367	169	03:35	20720
451	368-439	169	04:06	20720
452	440-511	169	04:36	20720
453	512-583	169	05:05	20720
454	584-655	169	05:35	20720
455	656-727	169	06:05	20720
456	728-799	169	06:33	20720
457	800-871	169	07:02	20720
458	872-943	169	07:32	20720
459	944-945	169	08:01	20720
460	953-1044	169	08:07	16624
461	1045-1134	169	08:36	16624
462	1135-1225	169	09:07	16624
463	1226-1316	169	09:36	16624
464	1317-1407	169	10:06	16624
465	1408-1498	169	10:37	16624
466	1499-1589	169	11:08	16624
467	1590-1680	169	11:39	16624
468	1681-1771	169	12:10	16624
469	1772-1862	169	12:40	16624
470	1863-1953	169	13:11	16624
471	1954-2044	169	13:42	16624
472	2045-2135	169	14:14	16624
473	2136-2226	169	14:44	16624
474	2227-2318	169	15:15	16624
475	2319-2409	169	15:45	16624
476	2410-2500	169	16:17	16624
477	2501-2591	169	16:50	16624
478	2592-2682	169	17:22	16624
479	2683-2773	169	17:56	16624
480	2774-2864	169	18:28	16624
481	2865-2955	169	19:01	16624
482	2956-2992	169	19:35	16624

NIC90C

Tape(reel)	Shots	JDay	Start Time	Rec. Length
483	3000-3090	169	19:52	16624
484	3091-3091	169		16624
485	3098-3188	169	20:24	16624
*486	3189-3189	169	20:55	16624
487	3196-3286	169	20:57	16624
488	3287-3377	169	21:27	16624
489	3378-3468	169	21:56	16624
490	3469-3559	169	22:26	16624
491	3560-3650	169	22:55	16624
492	3651-3741	169	23:26	16624
493	3742-3785	169	23:55	16624

Appendix 2: Tape Listing

NIC100

Tape(reel)	Shots	JDay	Start Time	Rec. Length
494	1-91	170	00:25	16624
495	92-184	170	00:56	16624
496	185-275	170	01:28	16624
497	276-366	170	01:59	16624
498	367-457	170	02:33	16624
499	462-548	170	03:05	16624
500	549-639	170	03:45	16624
501	640-730	170	04:17	16624
502	731-821	170	04:50	16624
503	822-912	170	05:23	16624
504	913-1003	170	05:57	16624
505	1004-1094	170	06:29	16624
506	1095-1186	170	07:02	16624
507	1187-1277	170	07:35	16624
508	1278-1368	170	08:08	16624
509	1369-1459	170	08:41	16624
510	1460-1550	170	09:14	16624
511	1551-1641	170	09:47	16624
512	1642-1732	170	10:20	16624
513	1733-1823	170	10:51	16624
514	1824-1914	170	11:23	16624
515	1915-2005	170	11:55	16624
516	2006-2096	170	12:28	16624
*517	2097-2104	170	13:02	16624

NOTE: reel 517 may be named 2109 after tape copying
skip in reel #s due to operator error

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2110	2110-2181	170	13:12	20720
2111	2182-2253	170	13:42	20720
2112	2254-2259	170	14:11	20720
2113	2260-2331	170	14:12	20720
2114	2332-2403	170	14:43	20720
2115	2404-2476	170	15:12	20720
2116	2477-2549	170	15:42	20720
2117	2550-2621	170	16:11	20720
2118	2622-2622	170	16:40	20720
2119	2628-2699	170	16:44	20720
2120	2700-2771	170	17:13	20720
2121	2772-2772	170	17:42	20720
2122	2777-2777	170	17:45	20720
2123	2778-2849	170	17:47	20720
2124	2850-2921	170	18:15	20720
2125	2922-2922	170	18:44	20720
*2126	**NO TAPE**			20720
*2127	**NO TAPE**			20720
2128	2934-3005	170	18:50	20720
2129	3006-3038	170	19:17	20720

NIC100C

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2140	1-91	170	20:35	16624
2141	92-182	170	21:06	16624
2142	183-274	170	21:36	16624
2143	275-365	170	22:06	16624
2144	366-456	170	22:37	16624
2145	457-547	170	23:10	16624
2146	548-638	170	23:40	16624

NIC110

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2147	1-72	171	00:24	20720
2148	73-144	171	00:55	20720
2149	145-216	171	01:23	20720
2150	217-288	171	01:52	20720
2151	289-360	171	02:23	20720
2152	361-432	171	02:52	20720
2153	433-504	171	03:21	20720
2154	505-576	171	03:51	20720
2155	577-648	171	04:20	20720
2156	649-720	171	04:49	20720
2157	721-792	171	05:18	20720
2158	793-864	171	05:47	20720
2159	865-936	171	06:17	20720
2160	937-1008	171	06:46	20720
2161	1009-1081	171	07:14	20720
2162	1082-1153	171	07:44	20720
2163	1154-1225	171	08:13	20720
2164	1235-1325	171	08:47	20720
2165	1326-1416	171	09:21	20720
2166	1417-1507	171	09:54	20720
2167	1508-1598	171	10:27	20720
2168	1599-1689	171	10:59	20720
2169	1690-1780	171	11:32	20720
2170	1781-1871	171	12:05	20720
2171	1872-1962	171	12:38	20720
2172	1963-2053	171	13:10	20720
2173	2054-2144	171	13:44	20720
2174	2145-2235	171	14:16	20720
2175	2236-2326	171	14:49	20720
2176	2327-2417	171	15:22	20720
2177	2418-2508	171	15:55	20720
2178	2509-2522	171	16:28	20720

NOTE: gap in shooting here due to computer failure

Tape(reel)	Shots	JDay	Start Time	Rec. Length
*2179	repeated by 110X	171	16:53	20720

NIC110X

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2180	1-91	171	19:53	16624
2181	92-182	171	20:24	16624
2182	183-273	171	20:54	16624
2183	274-364	171	21:25	16624
2184	365-455	171	21:55	16624
2185	456-547	171	22:27	16624
2186	548-638	171	22:58	16624
2187	639-729	171	23:27	16624
2188	730-820	171	23:58	16624

NIC110X-continued

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2189	8221-837	172	00:30	16624

NIC125H

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2200	1-19	173	10:19	16624
2201	20-110	173	10:38	16624
2202	111-111	173	12:10	16624
2203	114-131	173	12:14	16624
2204	132-222	173	12:30	16624
2205	223-240	173	14:03	16624
2206	241-331	173	14:22	16624
2207	332-350	173	15:52	16624
2208	351-441	173	16:12	16624
2209	442-461	173	17:40	16624
2210	462-552	173	17:58	16624
2211	553-572	173	19:27	16624
2212	573-663	173	19:49	16624
2213	664-683	173	21:11	16624
2214	684-774	173	21:28	16624
2215	775-794	173	22:53	16624
2216	795-885	173	23:13	16624
2217	886-905	174	00:36	16624
2218	906-996	174	00:56	16624
*2219	**NO TAPE**			16624
2220	1000-1018	174	02:18	16624
2221	1019-1109	174	02:40	16624
*2222	**NO TAPE**			16624
2223	1113-1132	174	04:01	16624
2224	1133-1223	174	04:24	16624
*2225	**NO TAPE**			16624
2226	1230-1248	174	05:54	16624
2227	1249-1339	174	06:09	16624
2228	1340-1359	174	07:34	16624
2229	1360-1450	174	07:53	16624
2230	1451-1471	174	09:17	16624
2231	1472-1527	174	09:36	16624

NIC125C

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2232	1540-1631	174	10:40	16624
2233	1632-1722	174	11:11	16624
2234	1723-1811	174	11:41	16624

NIC125D

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2235	1-91	174	12:26	16624
2236	92-182	174	12:57	16624
2237	183-273	174	13:29	16624
2238	274-364	174	14:00	16624
2239	365-372	174	14:30	16624

NIC115

Tape(reel)	Shots	JDay	Start Time	Rec. Length
2240	1-91	174	14:42	16624
2241	92-182	174	15:18	16624
2242	183-273	174	15:52	16624
2243	274-364	174	16:27	16624
2244	365-455	174	16:59	16624
2245	456-546	174	17:31	16624
2246	547-637	174	18:04	16624
2247	638-728	174	18:37	16624
2248	729-819	174	19:10	16624
2249	820-910	174	19:42	16624
2250	911-1002	174	20:17	16624
2251	1003-1096	174	20:49	16624
2252	1097-1187	174	21:24	16624
2253	1188-1278	174	21:56	16624
2254	1279-1369	174	22:30	16624
2255	1370-1460	174	23:03	16624
2256	1461-1552	174	23:36	16624
2257	1553-1643	175	00:13	16624
2258	1644-1734	175	00:46	16624
2259	1735-1825	175	01:20	16624
2260	1826-1916	175	01:55	16624
2261	1917-2007	175	02:31	16624
2262	2008-2098	175	03:04	16624
2263	2099-2189	175	03:38	16624
2264	2190-2280	175	04:11	16624
2265	2281-2371	175	04:44	16624
2266	2372-2462	175	05:17	16624
2267	2463-2553	175	05:50	16624
2268	2554-2644	175	06:23	16624
2269	2645-2735	175	06:56	16624
2270	2736-2826	175	07:29	16624
2271	2827-2917	175	08:02	16624
2272	2918-3008	175	08:35	16624
2273	3009-3099	175	09:08	16624
2274	3100-3190	175	09:40	16624
2275	3194-3281	175	10:13	16624
2276	3282-3372	175	10:45	16624
2277	3373-3463	175	11:18	16624
2278	3464-3554	175	11:51	16624
2279	3555-3645	175	12:23	16624
2280	3646-3736	175	12:57	16624
2281	3737-3827	175	13:30	16624
2282	3828-3918	175	14:04	16624
2283	3919-4002	175	1436	16624

* Missing tape or information.