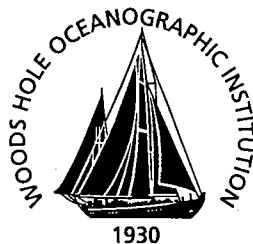


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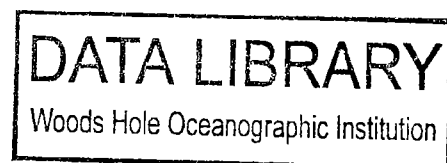
Woods Hole Oceanographic Institution



Preliminary Acoustic and Oceanographic Observations from the Winter Primer Experiment

By

Arthur Newhall
Keith Von der Heydt
Brian Sperry
Glen Gawarkiewicz
Jim Lynch



October 1998

Technical Report

Funding was provided by the Office of Naval Research under Contract No. N00014-98-10413.

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WHOI-98-19

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Timothy Stanton

Department of Applied Ocean Physics and Engineering



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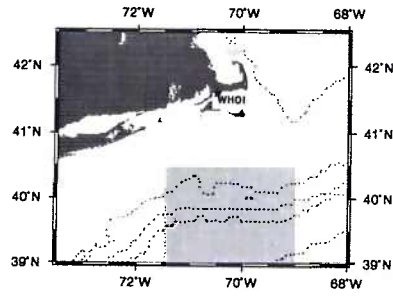
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1.0 Introduction

A joint acoustics and physical oceanography experiment was conducted in the winter of 1997 on the shelfbreak and continental slope south of New England in the Middle Atlantic Bight (figure 1). This experiment, Primer4, provided a seasonal contrast to the previous summer Primer3 experiment and had the same goals and tasks: to study the thermohaline variability and structure of the shelfbreak front and its effects on acoustic propagation. To accomplish the linked oceanographic and acoustic objectives of this experiment, a combination of measurements (fig 2) were made. Seasoar hydrography, shipboard ADCP measurements, Satellite IR sea surface temperature field observations, and AXBT drops were employed to study the larger scale oceanographic fields. To study the finer scale, which includes internal waves, a number of rapid-sampling thermistor strings and current meters, including a moored, upward looking ADCP, were deployed. The acoustics components consisted of three 400 Hz tomography transceivers, a 224 Hz source and two hydrophone arrays. To study the geoacoustic parameters in the bottom a number of SUS charges were also deployed. The field setup was approximately the same for both the summer 1996 and winter 1997 experiments; however the weather conditions and the thermal structure of the mixed layer were radically different. This report is dedicated to the data from the Winter 1997 Primer4 experiment. All data seen here are available online at <ftp://acoustics.whoi.edu> with permission from the author.





PRIMER IV Field Study February, 1997

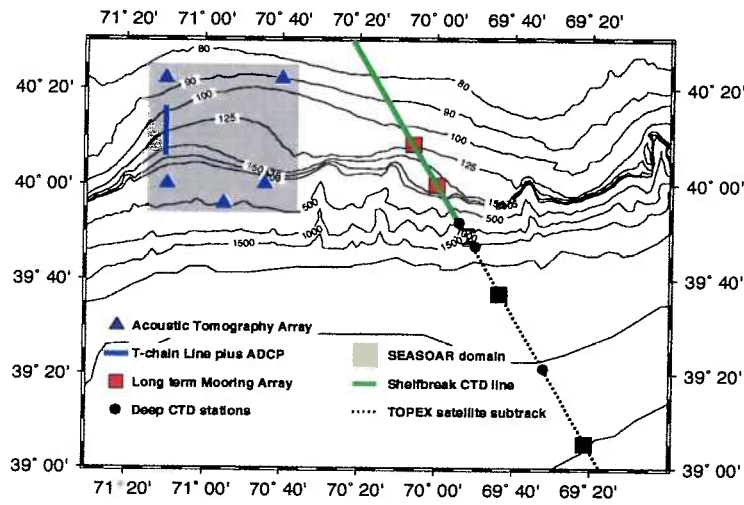


FIGURE 1. Primer4 area of study

February 1997

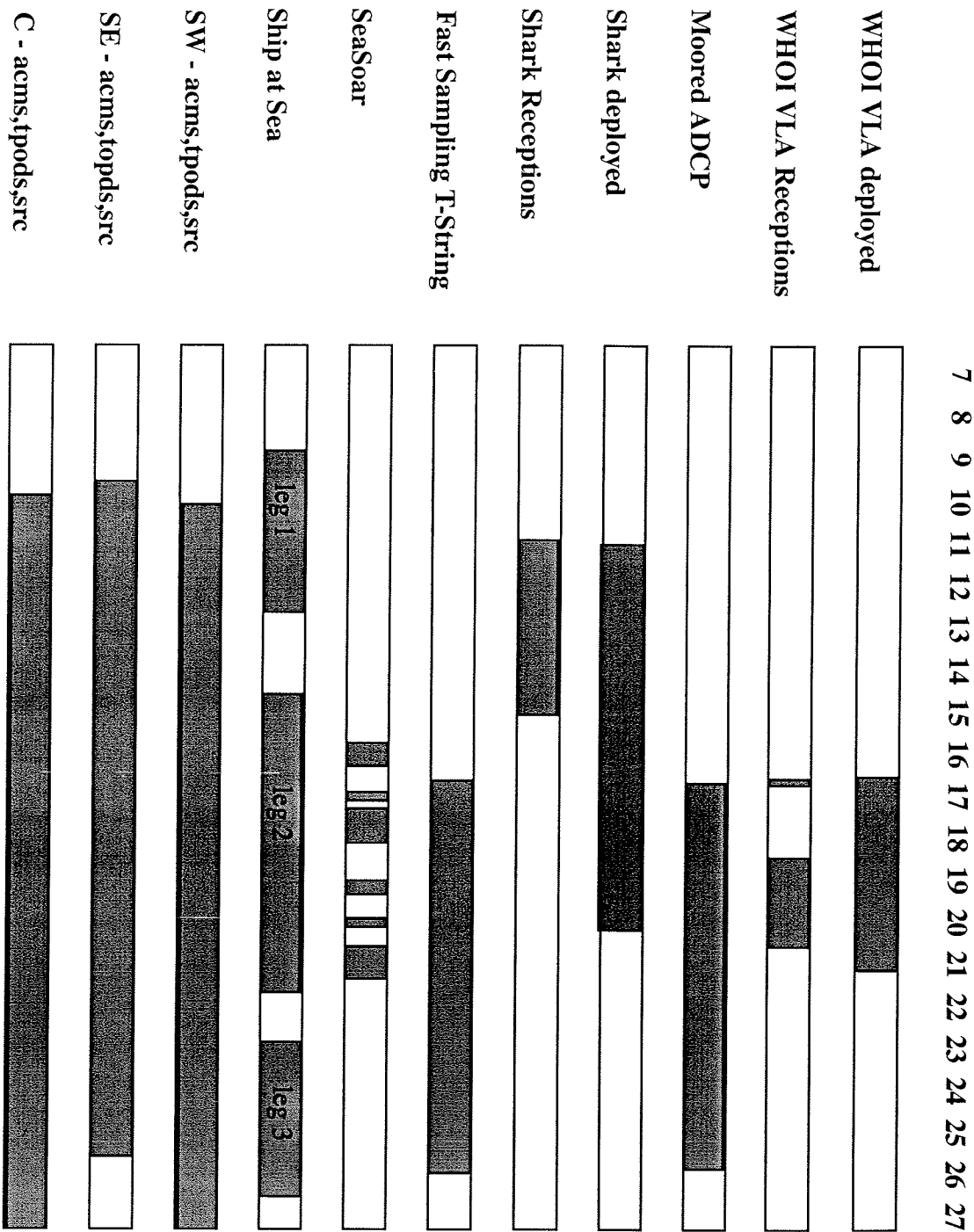


FIGURE 2. Primer4 timeline

2.0 Instrumentation and personnel

Environmental sampling was provided by a moored bottom-mounted ADCP, vertical CTD casts, a field of XBT's, a moored, fast-sampling thermistor chain, satellite sea surface temperature observations, a shipboard ADCP, temperature sensors and current meters attached to the acoustic moorings and large scale SeaSoar hydrography. The acoustic sources used during the experiment were three 400 Hz Webb sources, a 224 Hz Webb source, and air-dropped SUS charges. Two vertical hydrophone systems were used to gather and store acoustic data. One array also provided a horizontal array of hydrophones for a brief time. The western edge of the study area was heavily instrumented while the Eastern edge was relatively sparsely sampled to avoid interfering with submarine lanes near the eastern section (fig 3).

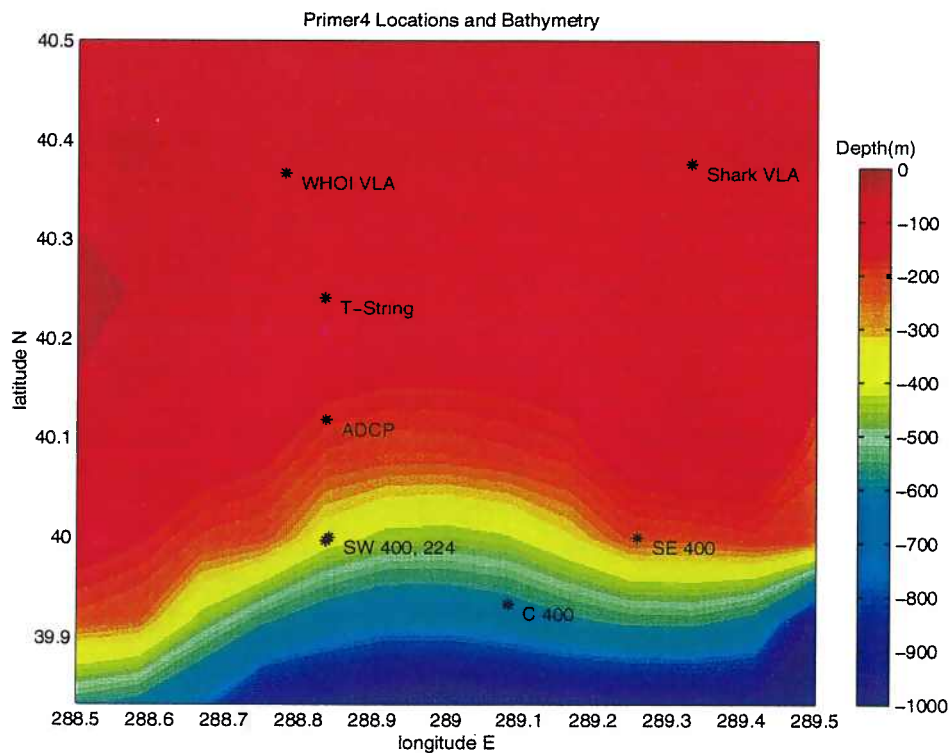


FIGURE 3. Primer4 bathymetry

2.1 Personnel

The ONR sponsored Primer4 experiment was a joint venture that included the Woods Hole Oceanographic Institution (WHOI) AOPE and PO departments, the University of Rhode Island (URI), the Naval Postgraduate School (NPS), Harvard University, and the Lamont-Doherty Earth Observatory (LDEO) at Columbia University (appendix 6.1). The research vessel R/V ENDEAVOR was used for both the summer and winter cruises.

2.2 SeaSoar

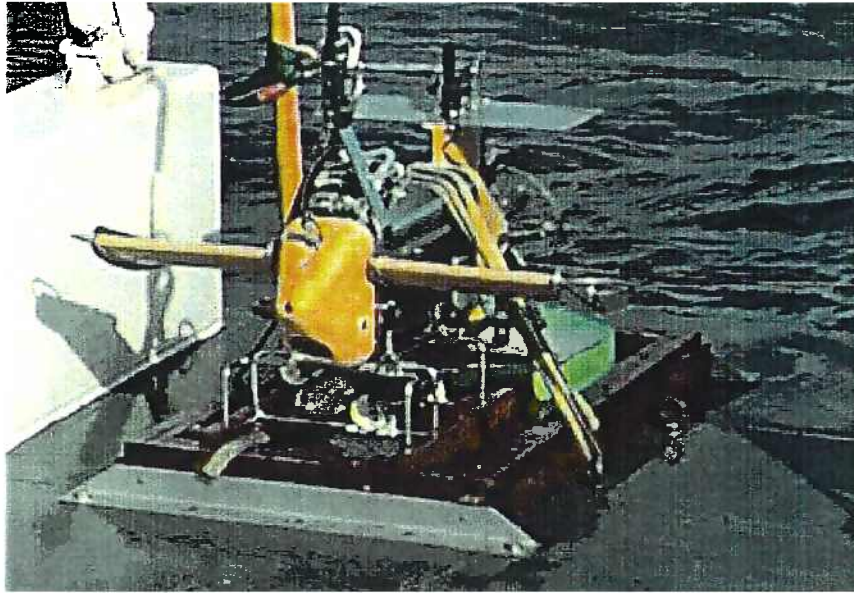


FIGURE 4. SeaSoar secured on deck and ready for deployment.

One of the primary limitations in studies of frontal thermohaline and velocity structure has been the inability to resolve the frontal structure with traditional CTD sampling. The SeaSoar vehicle is a towed, winged vehicle (fig 4) which quickly samples the water column. It can resolve thermohaline structure on horizontal scales of 0.5 to 1 km and can sample continuously while steaming at 7 knots (figs 5,6). SeaSoar operations were conducted to measure the thermohaline structure in winter conditions and to compare that with the previous summer experiment. The SeaSoar sampled on a series of grids that roughly encompassed the acoustic transmission paths. Each grid consisted of a series of cross frontal sections separated by 10 km in the along-shelf direction (fig 7). While operations were hindered, as anticipated, by strong winds and rough seas, three complete grids were occupied. Each grid consisting of four cross-shelf transects. Two additional partial grids were also sampled during the six days of SeaSoar operations. SeaSoar sensors measured temperature, salinity, conductivity, fluorescence, transmissivity and bioluminescence. For more information on the SeaSoar, see website <http://matisse.who.edu>.

TABLE 1. SeaSoar operations

| | |
|--------------|------------------------------|
| deployment 1 | 2/16/97 1403 -> 2/17/97 0000 |
| deployment 2 | 2/17/97 1347 -> 2/17/97 1700 |
| deployment 3 | 2/18/97 0039 -> 2/18/97 1800 |
| deployment 4 | 2/19/97 1750 -> 2/20/97 0100 |
| deployment 5 | 2/20/97 1412 -> 2/20/97 2000 |
| deployment 6 | 2/21/97 0412 -> 2/22/97 0000 |

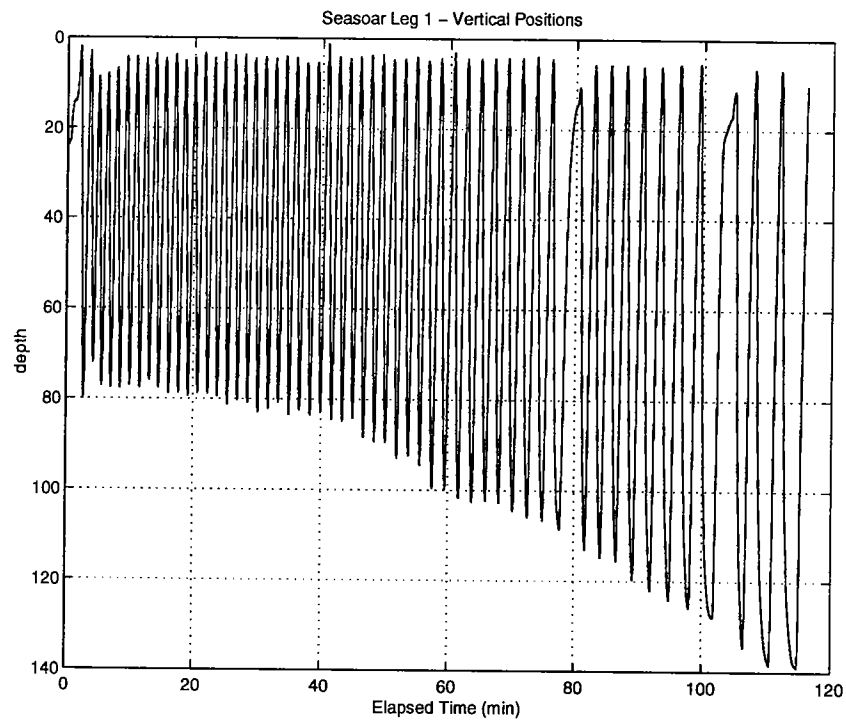


FIGURE 5. SeaSoar undulations for leg 1

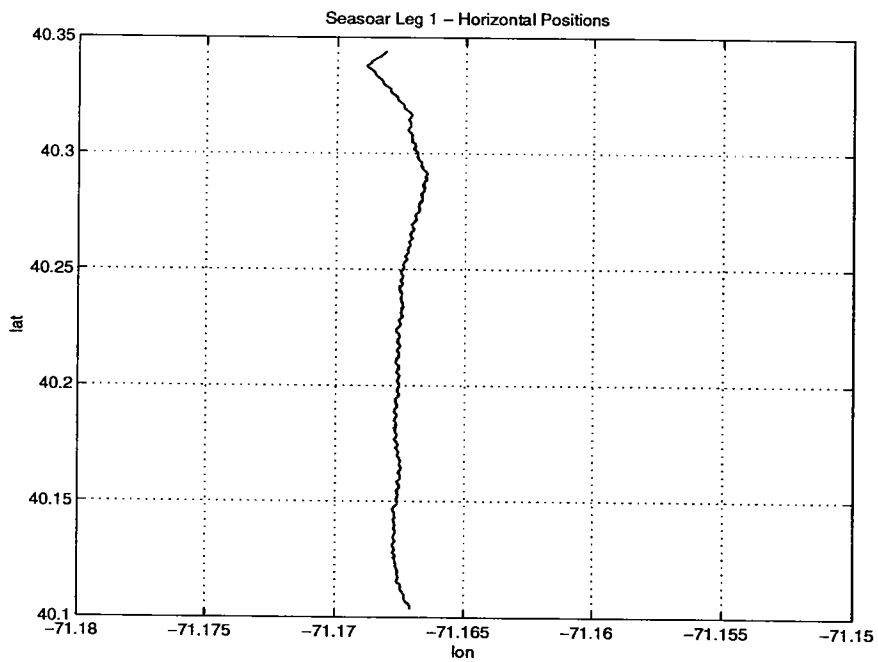


FIGURE 6. SeaSoar horizontal locations for leg 1

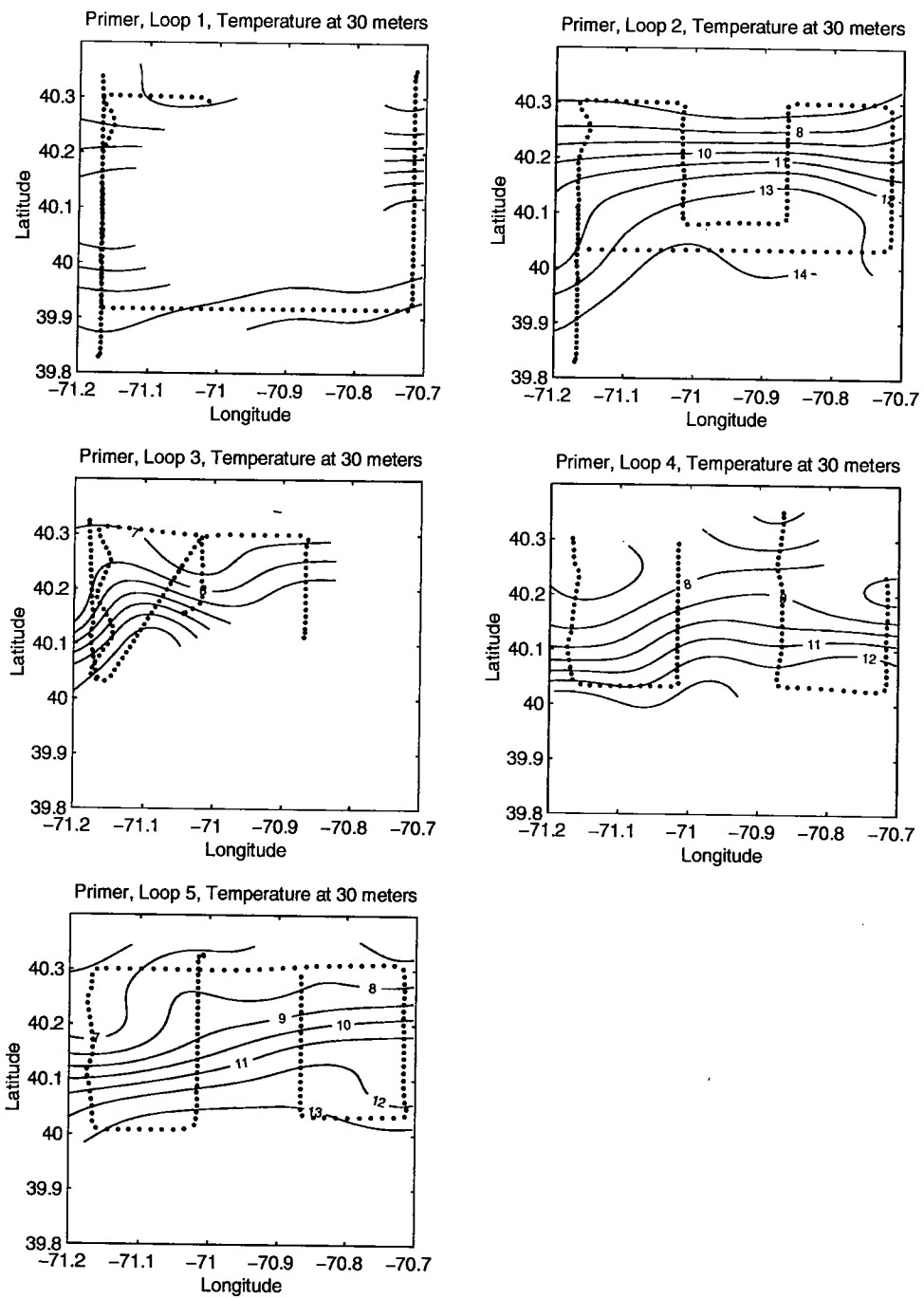


FIGURE 7. Seasoar grids with temperature contours for 30 meter depth.

2.3 Moored ADCP

A moored RDI Instruments, narrow band, self-contained, 300 kHz Acoustic Doppler Current Profiler (ADCP) was moored partway between the SW sources and the WHOI Vertical Line Array (VLA) on the Western leg. The ADCP was attached to the anchor so it sat on the bottom and looked upward (appendix 6.2). The transducer depth was 145 meters. Each vertically sampled velocity bin is 4 meters in length and the depth of the bin is defined by its center (+2 meters from start of bin). The entire water column was sampled with fewer data bins than the ADCP provided. Extra data bins contain irrelevant data and some of the near surface bins contained acoustic reflections that made them useless. Heading corrections, sound speed corrections, and magnitude declination corrections were all enabled.

Data is stored using filenames that are numbered sequentially from the start of logging on Feb. 10, 1997 (i.e 001.dat). The ADCP stayed on deck awaiting deployment for 6 days. The first datafile that contains usable data starts with filename number 016. The data files contain bin number, depth of center of bin, and east, north and upward velocity components. The up/down velocity component was very small (fig 8), roughly 1 cm/sec, and is probably mostly noise. The east and north components at 35 meters (fig 9) show a primarily SE direction. Figure 10 shows the entire water column velocities.

TABLE 2. Moored ADCP

| | |
|--------------------------|------------------|
| deployed | 2/17/97 1014 (Z) |
| recovered | 2/26/97 1610 (Z) |
| latitude N | 40 07.1283 |
| longitude W | 71 09.8602 |
| depth (m) | 150 |
| logging started | 2/10/97 1200 (Z) |
| sampling interval (min) | 1.5 |
| number of pings averaged | 225 |

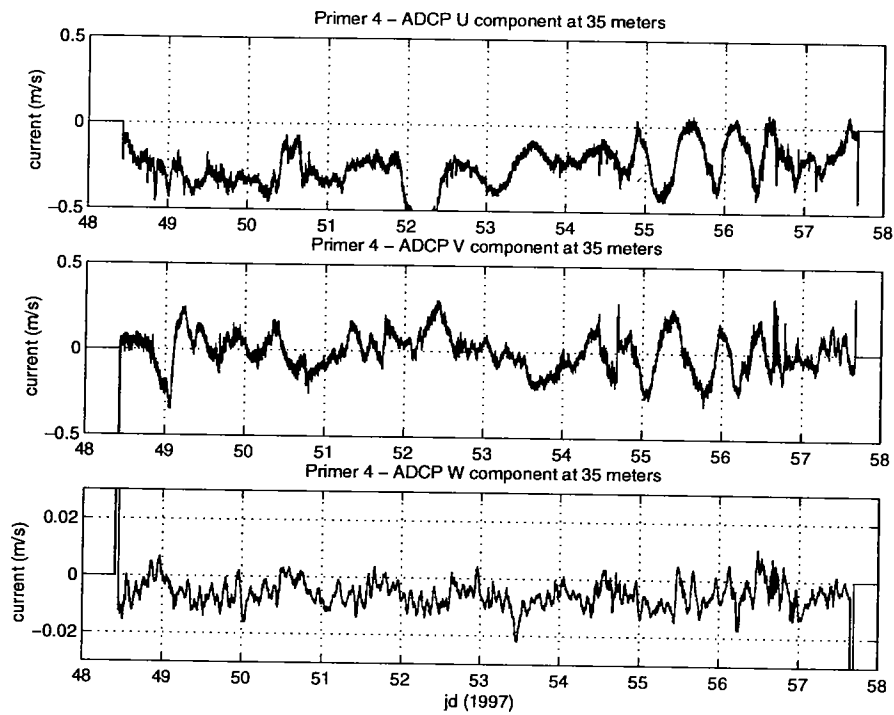


FIGURE 8. ADCP east, west and upward components at 35 meters depth

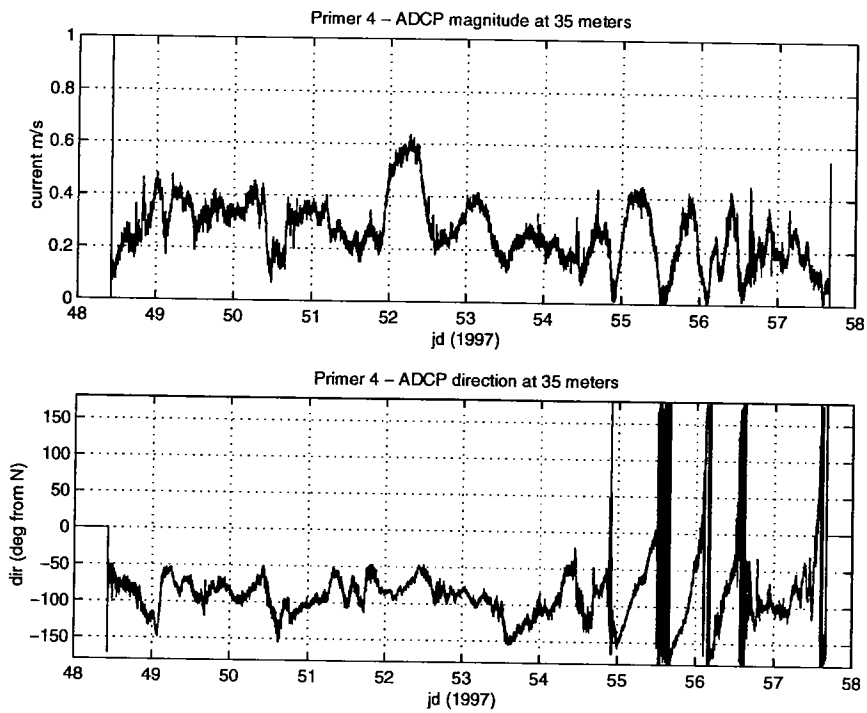


FIGURE 9. ADCP magnitude and phase at 35 meters depth

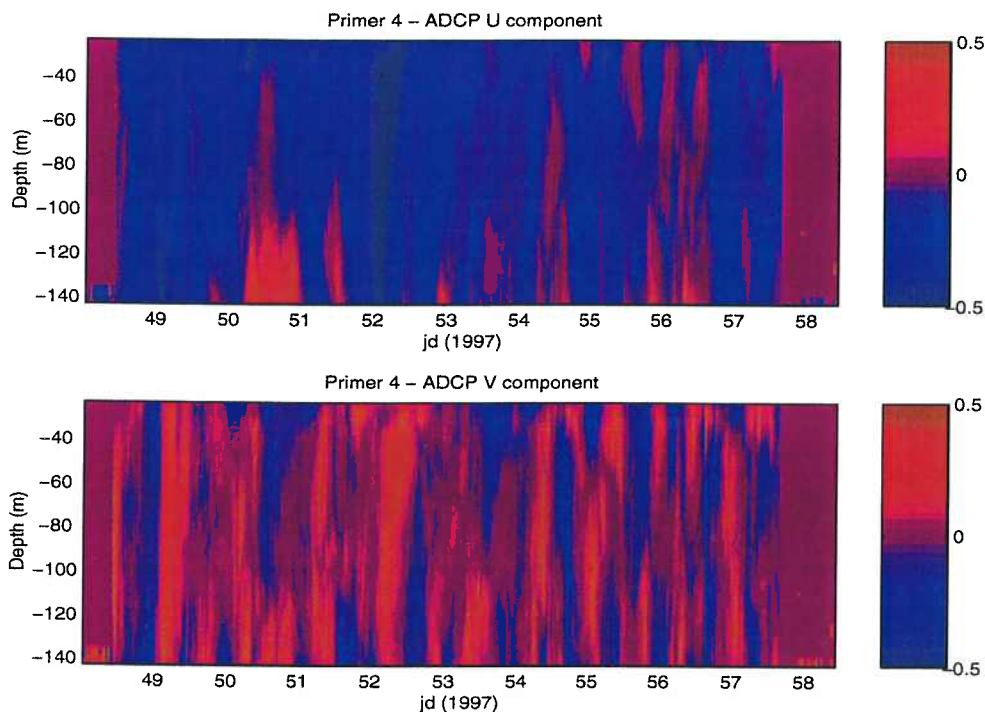


FIGURE 10. ADCP U(eastward) and V(northward) components for entire water column

2.4 Fast-sampling thermistor string

A fast-sampling thermistor string (also see appendix 6.2) was positioned on the western edge of the acoustic field between the WHOI VLA and the SW sources (fig 3) to measure internal waves as they propagated onshore. The T-string sampled temporally every 4 seconds and spatially sampled the water column from 26 meters to 100 meters depths at variable depth increments (see table below). Individual temperature sensors were attached to the mooring at the surface and at the bottom to complete the sampling of the entire water column. Significant subtidal period and internal wave period variability is seen (figs 11-13).

TABLE 3. Fast Sampling Thermistor String

| | |
|-------------------|------------------|
| deployed | 2/17/97 0827 (Z) |
| recovered | 2/26/97 1755 (Z) |
| latitude N | 40 14.4889 |
| longitude W | 71 09.9965 |
| depth | 104 meters |
| sampling interval | 4 seconds |

TABLE 4. Thermistor Depths

| Thermistor | Depth (meters) |
|------------|-------------------|
| t-pod #958 | 1 |
| # 1 | 26 |
| # 2 | 27 |
| # 3 | 28 |
| # 4 | 30 |
| # 5 | 32 (Did not work) |
| # 6 | 36 (Did not work) |
| # 7 | 40 |
| # 8 | 44 (Did not work) |
| # 9 | 52 |
| #10 | 60 (Did not work) |
| #11 | 68 |
| #12 | 84 |
| #13 | 100 |
| #14 | 101 |
| t-pod #956 | 102 |

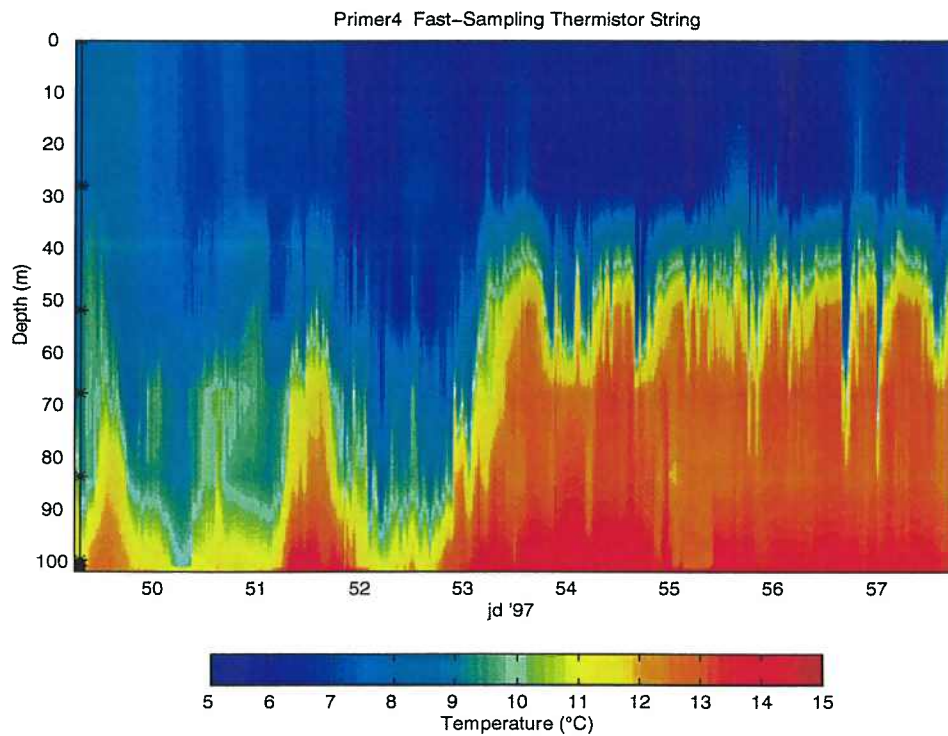


FIGURE 11. Fast sampling thermistor string for entire deployment

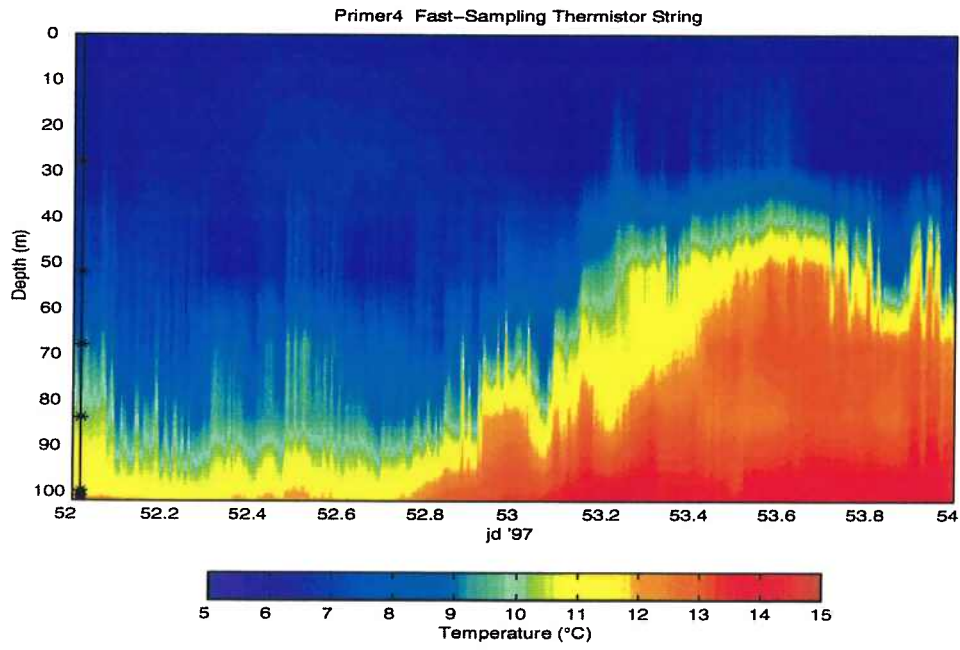


FIGURE 12. Days 53 to 54 from above fast sampling temperature string

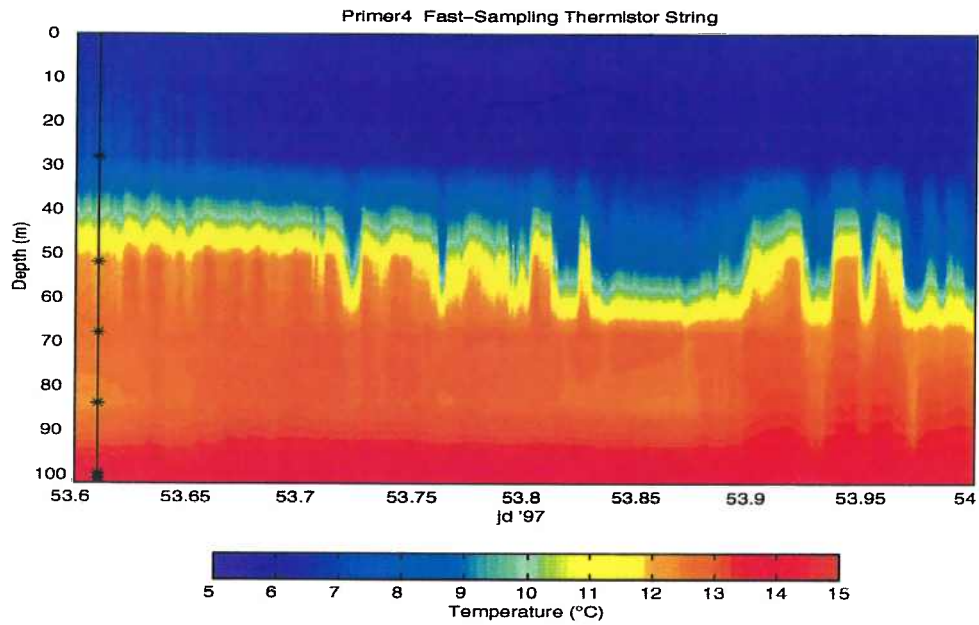


FIGURE 13. Noon to midnight (Z) for day 53

2.5 AXBT's

On Feb 14th, from 1630 to 2200 hrs (local time), thirty five AXBT's were dropped along lines both inside and outside the tomography area (fig 14) to measure temperature on a large spatial scale. While the profiles contained some noise (figs 15,16,,17), the data can be filtered to extract useful temperatures (fig 18) which show frontal temperature following the bathymetry (fig 19) but with a large northbound intrusion at longitude 71.2 degrees W.

TABLE 5. AXBT times and location

| time (local) | latitude (N) | longitude (W) |
|-------------------------|---------------------|----------------------|
| 1631 | 40 42.0000 | 71 09.3550 |
| 1650 | 40 29.0783 | 71 23.8250 |
| 1705 | 40 17.8967 | 71 37.7767 |
| 1714 | 40 42.7750 | 71 36.9300 |
| 1723 | 40 42.5717 | 70 40.3983 |
| 1730 | 40 42.0917 | 70 12.4317 |
| 1737 | 40 28.5350 | 70 12.2217 |
| 1746 | 40 28.9150 | 70 56.5583 |
| 1810 | 40 18.1167 | 71 28.1783 |
| 1817 | 40 16.9000 | 71 04.9850 |
| 1828 | 40 16.0667 | 70 55.0000 |
| 1835 | 40 17.2283 | 70 44.6450 |
| 1842 | 40 17.0383 | 70 33.5117 |
| 1853 | 40 18.0567 | 70 12.4717 |
| 1900 | 40 09.7433 | 70 11.3159 |
| 1907 | 40 09.5533 | 70 23.7100 |
| 1914 | 40 10.5200 | 70 33.9583 |
| 1938 | 40 10.7767 | 70 44.7417 |
| 1946 | 40 11.0267 | 70 55.0567 |
| 1957 | 40 16.7367 | 71 05.8233 |
| 2012 | 40 10.7317 | 71 16.5550 |
| 2022 | 40 01.9350 | 71 39.5833 |
| 2031 | 40 01.7083 | 71 26.5150 |
| 2042 | 40 01.5367 | 71 05.3867 |
| 2053 | 40 01.3967 | 70 50.8517 |
| 2106 | 40 01.4800 | 70 44.5300 |
| 2116 | 40 00.9317 | 70 33.1617 |
| 2123 | 39 59.2083 | 70 23.4383 |
| 2134 | 40 00.5417 | 70 12.5383 |

TABLE 5. AXBT times and location

| time (local) | latitude (N) | longitude (W) |
|--------------|--------------|---------------|
| 2139 | 39 52.2150 | 70 12.8467 |
| 2145 | 39 51.4950 | 70 26.9383 |
| 2157 | 39 51.2283 | 70 39.7283 |
| 2203 | 39 51.1917 | 71 09.2417 |
| 2211 | 39 50.9033 | 71 23.4250 |
| 2218 | 39 51.2767 | 71 37.6017 |

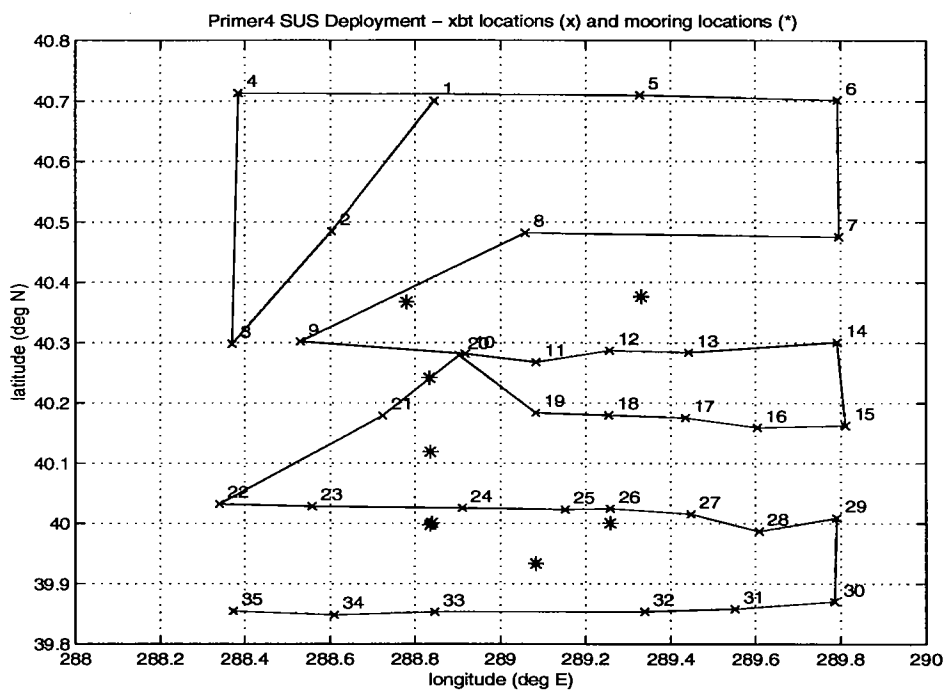


FIGURE 14. AXBT and mooring locations

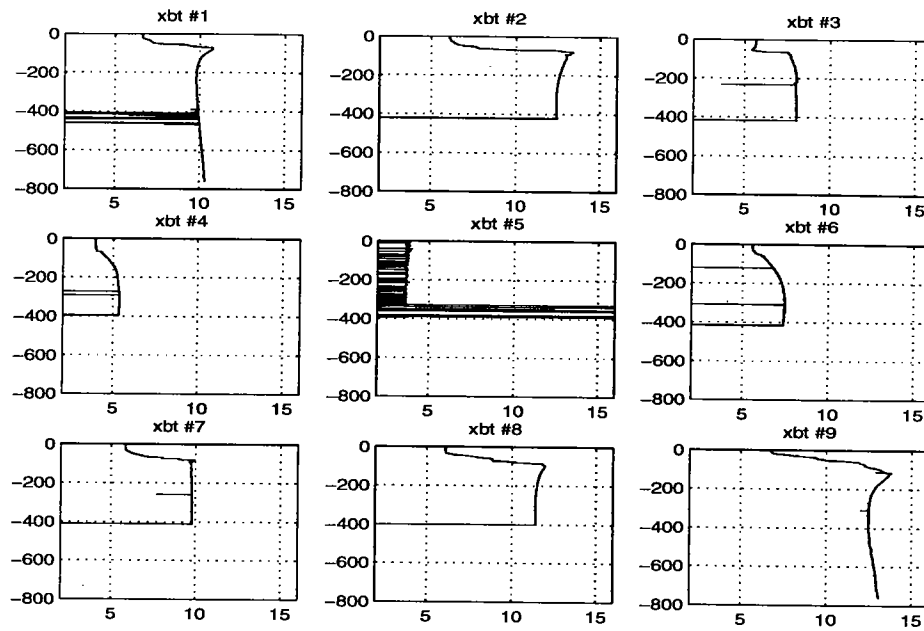


FIGURE 15. AXBT temperature (degrees C) vs depth (m) profiles for drops 1-9.

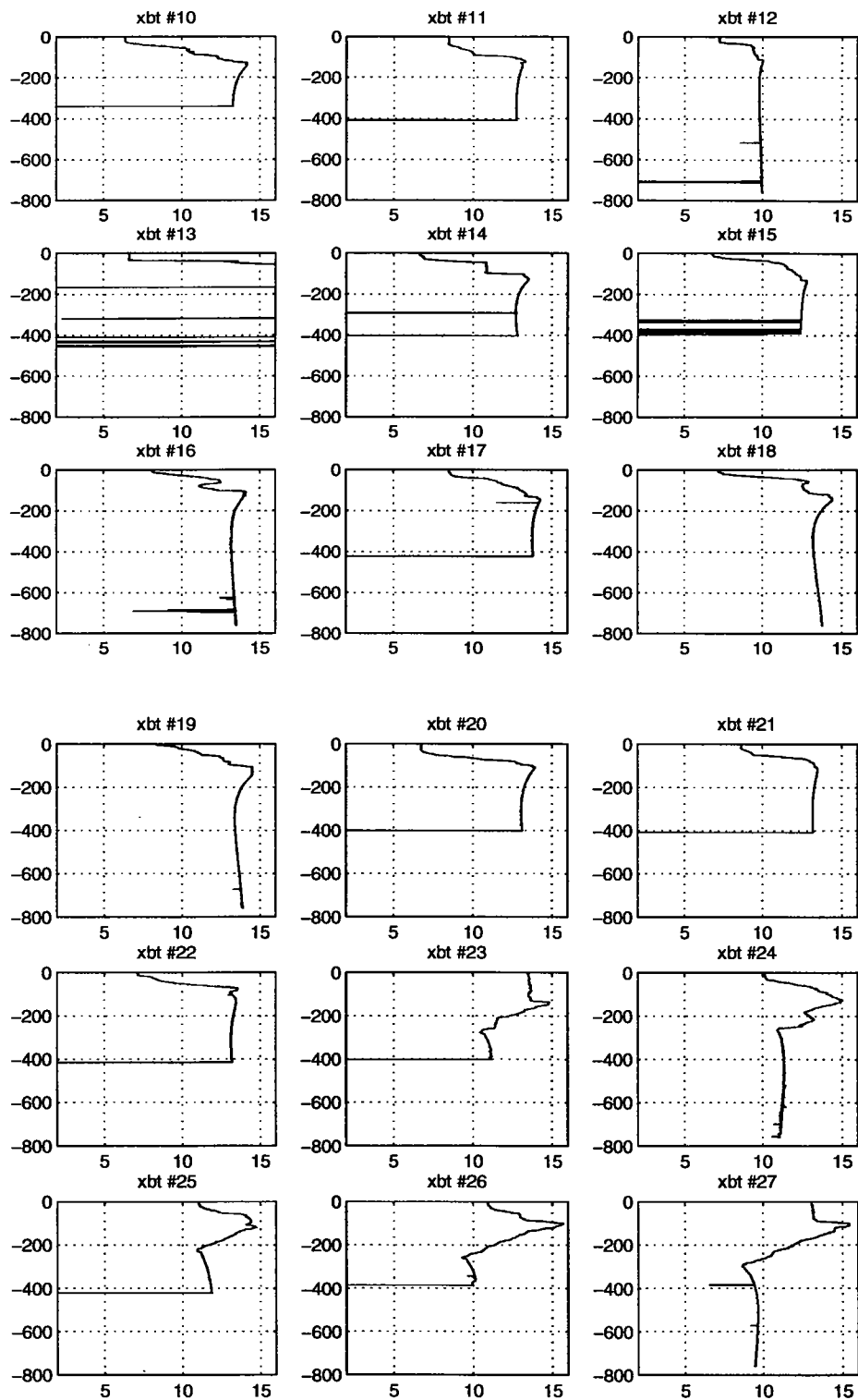


FIGURE 16. AXBT temperature (degrees C) vs depth (m) profiles for drops 10-27.

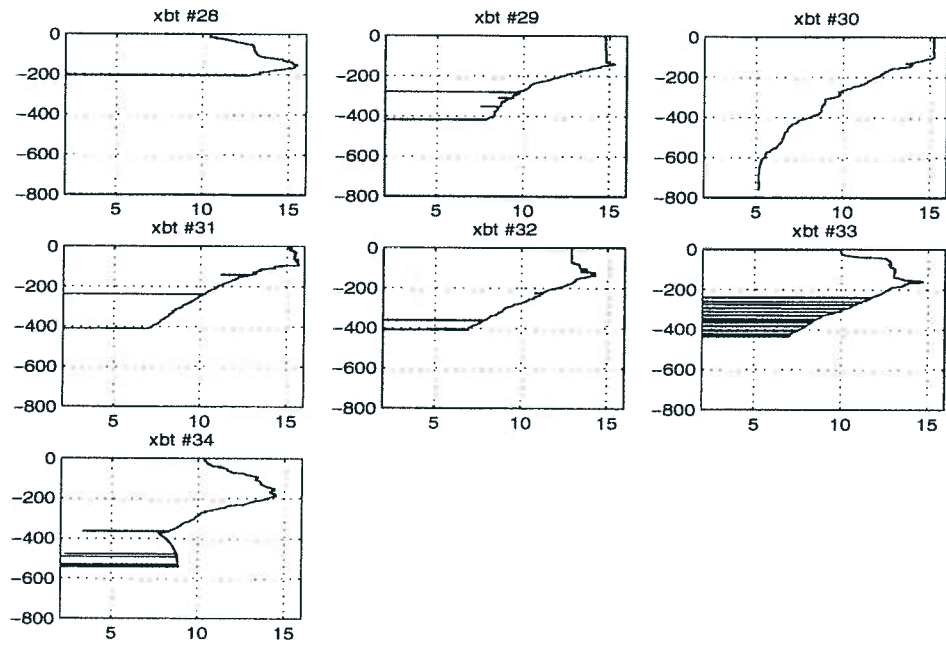


FIGURE 17. AXBT temperature (degrees C) vs depth (m) profiles for drops 28-34

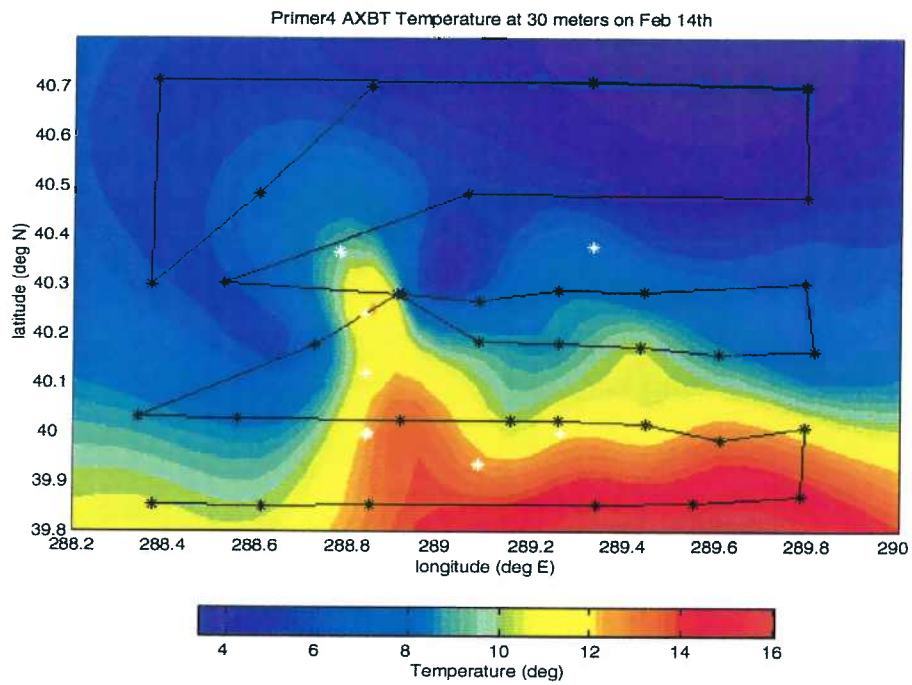


FIGURE 18. AXBT temperature contours at 30 meters depth

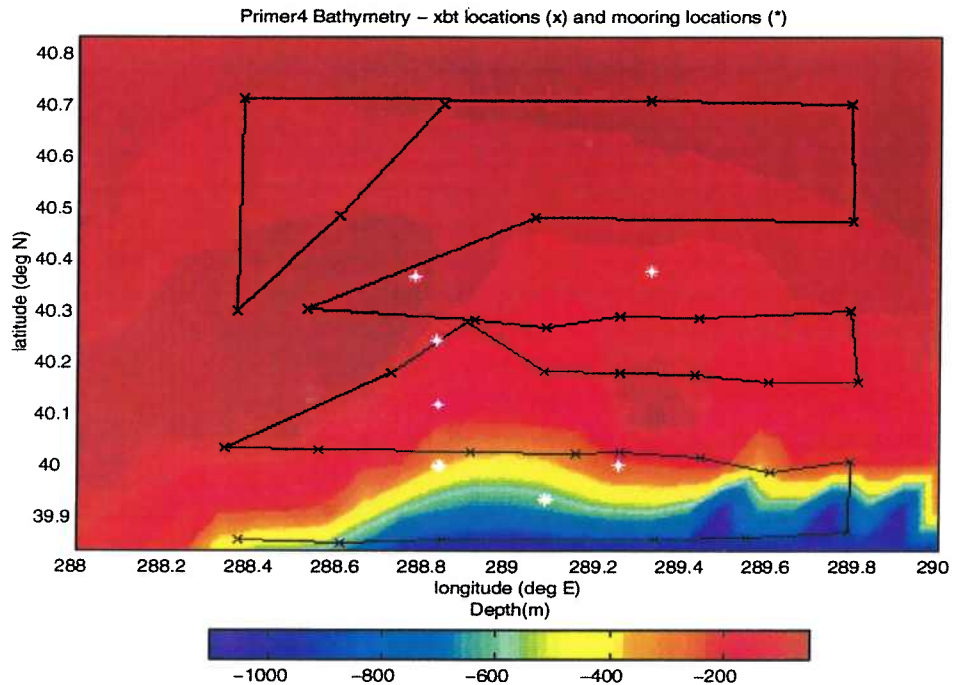


FIGURE 19. AXBT locations and bathymetry

2.6 Acoustic sources and short array moorings

Four Webb tomography organ pipe acoustic sources were moored along the south edge of the acoustic propagation study area. (fig 2). The moorings were named according to their position in the area (SouthWest, Central, SouthEast). Each location had a transceiver that contained a source which transmitted a 400 Hz phase encoded signal and contained a short 8 element array tuned to receive those 400 Hz signals. Each source was scheduled to transmit every 15 minutes starting at staggered times to prevent simultaneous transmissions. A 224 Hz source was also placed near the SW transceiver to study frequency-dependent acoustic propagation along the same paths (see appendix 6.2 for pre-deployment sketches). Both the SW 400 Hz and 224 Hz sources worked throughout the entire experiment. Unfortunately, the source at the Central location did not transmit. At recovery, the SE mooring source was still working, but at very low power. Post cruise inspection revealed that a transducer face had failed due to seawater leakage on the transducer face, disabling the transmitter electronics. At this point, the time of failure has not been identified.

All acoustic moorings were also equipped with temperature sensors to measure water column temperature variability. One sensor was always attached to the hi-flyer surface float at 1 meters below the surface and one was attached to the anchor to insure getting a sample of the entire water column. Sometimes the surface temperature sensors were lost due to fishing activity in the area.

2.6.1 "SW" 400 Hz source and short array mooring

The Southwest (SW) mooring consisted of a 400 Hz source (system #11) and an 8 element, tuned hydrophone array. This hydrophone array (#008) had 2 independent 4 hydrophone channels (A & B) for acquiring data. Data was stored according to the channel it was acquired on. This data is currently being analyzed by the Naval Postgraduate School investigators.

Navigation transponders were positioned in a triangle non-equidistant from the source to estimate mooring motion. The transponders were bottom mounted and were left from the Primer3 experiment. Acoustic surveys of the transponders were not conclusive for this site so the earlier Primer3 survey was used. Because of inclement weather, the SW source wasn't recovered during the Primer4 recovery phase. A special trip to the site was organized during July 1997 when the SW mooring was recovered. However, the upper half of the mooring was missing, apparently cut off by a fishing vessel.

On 8/30/97 at 40 11.0 N and 72 06.8 W, Captain Billy Bellande of the M/V Gulf Guardian recovered the top portion adrift about 100 miles offshore of Staten Island. The top portion included the three current meters, but tpod numbers 277, 278 and 280 were lost. The only tpod temperature sensor recovered was located at the bottom of the mooring. The ACMs also acquired temperature and depth, so some water column temperature data is available. The pressure sensor obviously malfunctioned since the depth data (fig 20) of #9613 does not match the mooring diagram. The ACM average depth is 50 meters but was configured to be at 25 m. Temperature data for water column (fig 21,22) shows warm water masses (slope water) centered at about 100 meter water depth.

Even after being cut and temporarily lost, all data from the ACM current data was recovered (figs 23, 24). Starting time for all the current meters was February 3, 1997 at 1700 hours. The ACMs were all set to sample every 5 minutes.

TABLE 6. SW tomography transceiver mooring

| | |
|-------------|-----------------------|
| system | 011 |
| array | 008 |
| deployed | 2/10/97 2057 (Z) |
| recovered | 7/19/97 1800 (Z) |
| latitude N | 39 59.8793 (surveyed) |
| longitude W | 71 09.9281 (surveyed) |
| water depth | 300 meters |

TABLE 7. SW mooring hydrophone locations for the short array

| Depth (m) | phone - channel |
|-----------|----------------------|
| 285 | phone #1 - channel A |
| 282.93 | phone #2 - channel A |
| 283.13 | phone #3 - channel A |
| 283.33 | phone #1 - channel B |

TABLE 7. SW mooring hydrophone locations for the short array

| Depth (m) | phone - channel |
|-----------|----------------------|
| 281.05 | phone #4 - channel A |
| 281.25 | phone #2 - channel B |
| 281.45 | phone #3 - channel B |
| 279.38 | phone #4 - channel B |

TABLE 8. SW mooring Aanderra current meters

| Depth (m) | Serial number | Starting time (Z) | Sampling interval |
|-----------|---------------|-------------------|-------------------|
| 25 | 9613 | Feb 3 @ 1700 hrs | 5 minutes |
| 60 | 10773 | Feb 3 @ 1700 hrs | 5 minutes |
| 100 | 9443 | Feb 3 @ 1700 hrs | 5 minutes |

TABLE 9. SW mooring temperature sensors

| Depth (m) | Serial number |
|-----------|---------------|
| 1 | 277 (lost) |
| 40 | 278 (lost) |
| 180 | 280 (lost) |
| 280 | 282 |

TABLE 10. SW mooring acoustic navigation

| transponder frequency | latitude (surveyed P3) | longitude (surveyed P3) |
|-----------------------|------------------------|-------------------------|
| 11.0 kHz | 40 00.2371 | 71 10.1248 |
| 11.5 kHz | 39 59.8946 | 71 10.4039 |
| 12.0 kHz | 39 59.7938 | 71 10.0271 |

TABLE 11. Recovery time check for SW source

| Grey Sailclock day hr min sec | Blue Sailclock day hr min sec | System Time day hr min sec |
|----------------------------------|----------------------------------|-------------------------------|
| 211 12 49 02.874897 | 211 12 49 02.832565 | 211 12 49 03 |
| 211 12 50 48.874885 | 211 12 50 48.832474 | 211 12 50 49 |
| 211 12 51 44.874897 | 211 12 51 44.832475 | 211 12 51 45 |

TABLE 12. SYS 11 - SW source mooring transmission schedule

| | |
|--|--------------------------------|
| system time (Z) (pre-deployment) | day 37 17 51 14 |
| UTC time (Z) (pre-deployment - grey) | day 37 17 51 14.000017 |
| source Depth (meters) | 288.5 |
| transmission times (minutes after the hour) | 0,20,40 |
| center frequency (Hz) | 400 |
| cycles per digit | 4 |
| digits per sequence | 511 (10 msec) |
| number of sequences transmitted | 70 (357.7 seconds total) |
| sequence length | 7128 |
| M-sequence law | 1533 (Octal) |
| reception times (minutes after hour) | 7,9,13,15,27,29,33,35,47,53,55 |
| number of sequences coherently averaged | 12 (61.32 secs) |
| clock drift (174 days) | .12512 secs |

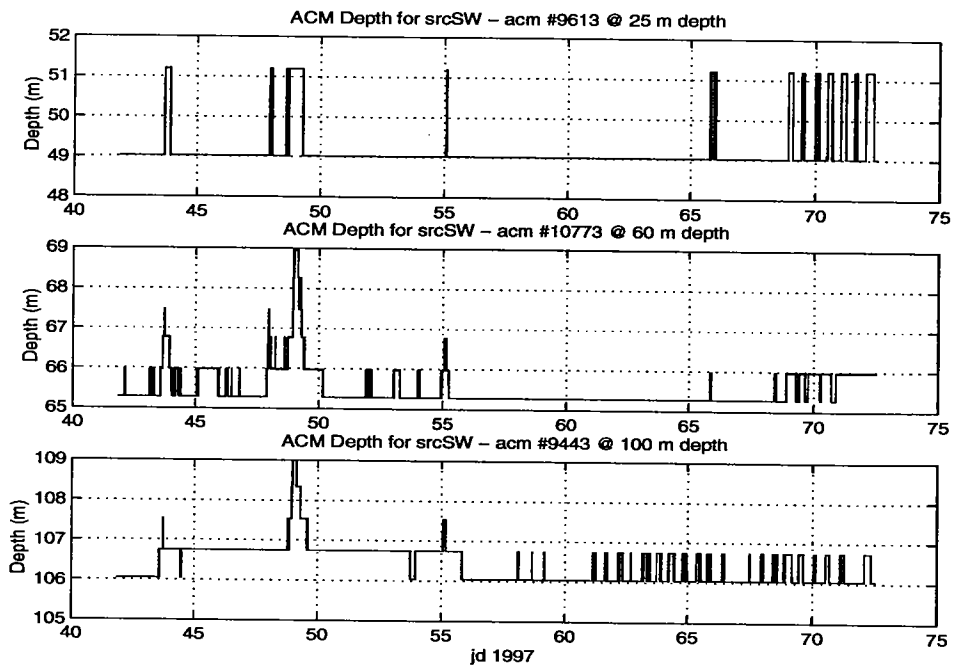


FIGURE 20. ACM recorded depths for SW mooring

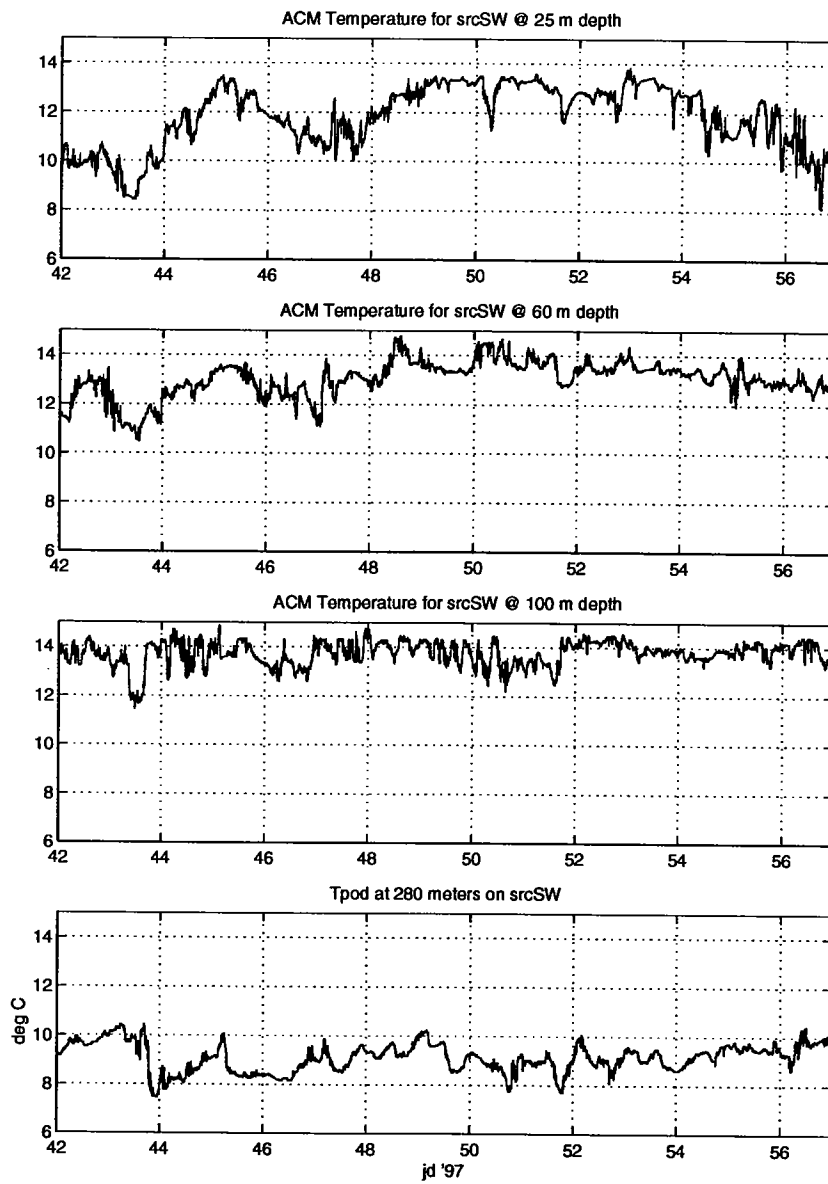


FIGURE 21. ACM temperature at 25, 60, 100 meters and tpod at 280 meters at SW mooring

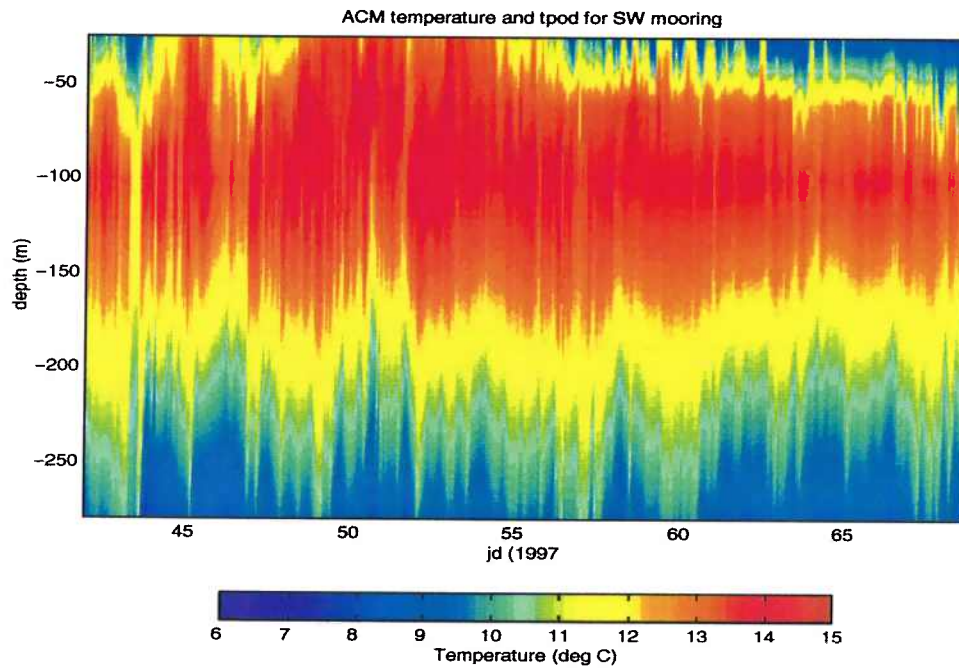


FIGURE 22. ACM temperature for all sensors at SW mooring

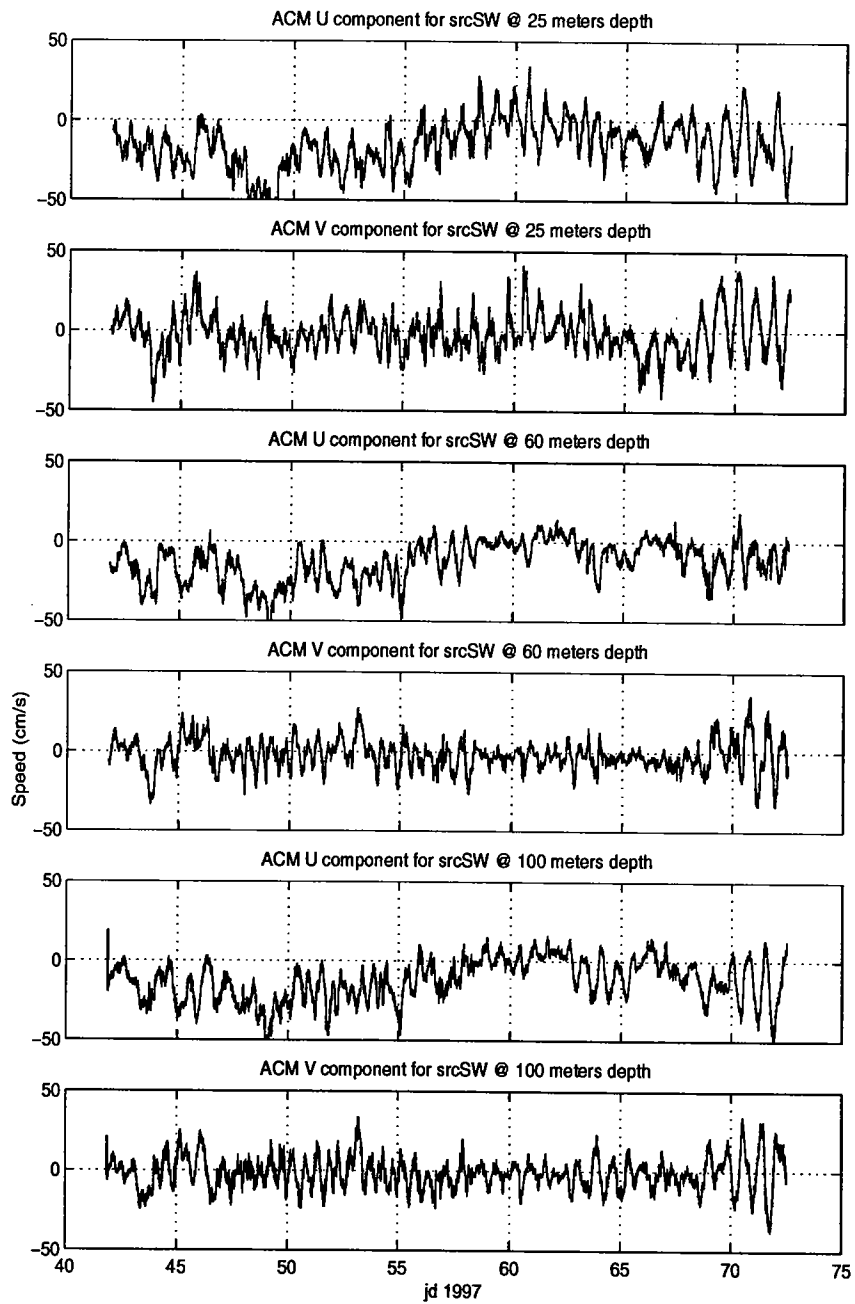


FIGURE 23. ACM U and V components for depths 25, 60, 100 meters at SW mooring

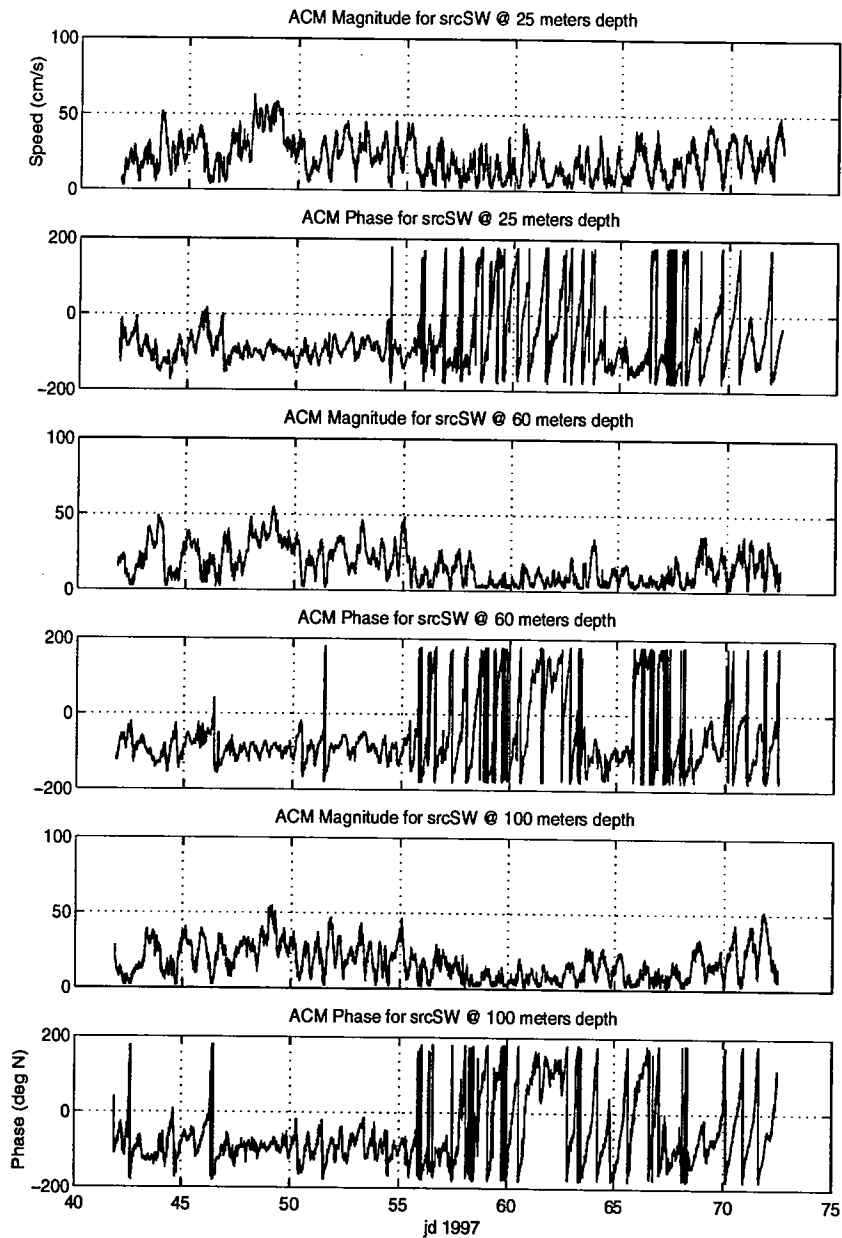


FIGURE 24. ACM magnitudes and phase for depths 25, 60, 100 meters at SW mooring

2.6.2 “C” 400 Hz source and short array mooring

Due to inclement weather, the Central “C” tomography transceiver mooring was recovered during the MOMAX experiment months after the Primer4 experiment ended. From looking at receptions from the “Shark of Science” Vertical Line Array (see VLA section

below), mooring C did not transmit. Data from the short hydrophone array connected to it, however, was recovered and the data is being analyzed by NPS. The internal clock drifted .0212 seconds. The single ACM had depth, temperature and current samples (figs 25,26,27,28). The Central mooring was not navigated for mooring motion due to the short length of the mooring giving a small watch circle.

TABLE 13. Central mooring "C"

| | |
|-------------|-----------------------|
| system | 009 |
| array | 014 |
| deployed | 2/10/97 0110 (Z) |
| recovered | 3/31/97 1450 (Z) |
| latitude N | 39 56.0390 (surveyed) |
| longitude W | 70 55.0254 (surveyed) |
| water depth | 459 meters |

TABLE 14. Central mooring "C" hydrophone array locations

| Depth (m) | phone - channel |
|-----------|-----------------|
| 446 | phone #1 - A |
| 443.93 | phone #2 - A |
| 444.13 | phone #3 - A |
| 444.23 | phone #1 - B |
| 442.05 | phone #4 - A |
| 442.25 | phone #2 - B |
| 442.45 | phone #3 - B |
| 440.38 | phone #4 - B |

TABLE 15. Central mooring Aandera current meters

| Depth (m) | Serial number | starting time | sampling interval |
|-----------|---------------|------------------|-------------------|
| 427 | 10769 | Feb 3 @ 1700 hrs | 5 minutes |

TABLE 16. Central mooring transceiver deployment time check

| System | Day | hour | minute | second |
|---------------|------------|-------------|---------------|---------------|
| sys09 | 041 | 15 | 51 | 36.000000 |
| UTC | 041 | 15 | 51 | 35.996039 |

TABLE 17. Central mooring transceiver recovery time check

| System | Day | hour | minute | second |
|---------------|------------|-------------|---------------|---------------|
| sys09 | 094 | 16 | 37 | 44.000000 |
| UTC | 094 | 16 | 37 | 44.017190 |

TABLE 18. SYS09 - Central mooring schedule

| | |
|--|----------------------------------|
| system time (pre-deployment) | day 37 18 51 57 |
| UTC time | day 37 18 51 56.999988 |
| source depth (meters) | 448 |
| transmission times (minutes after hour) | 12, 32, 52 |
| center frequency (Hz) | 400 |
| cycles per digit | 4 |
| digits per sequence | 511 (10 msec) |
| number of sequences transmitted | 70 (357.7 secs total) |
| sequence length | 7128 |
| M-seq law | 1021 (octal) |
| reception times (minutes after hour) | .5, 12.5, 20.5, 32.5, 40.5, 52.5 |
| number of sequences coherently averaged | 46 (235.06 secs) |
| clock drift (53 days) | .021151 seconds |

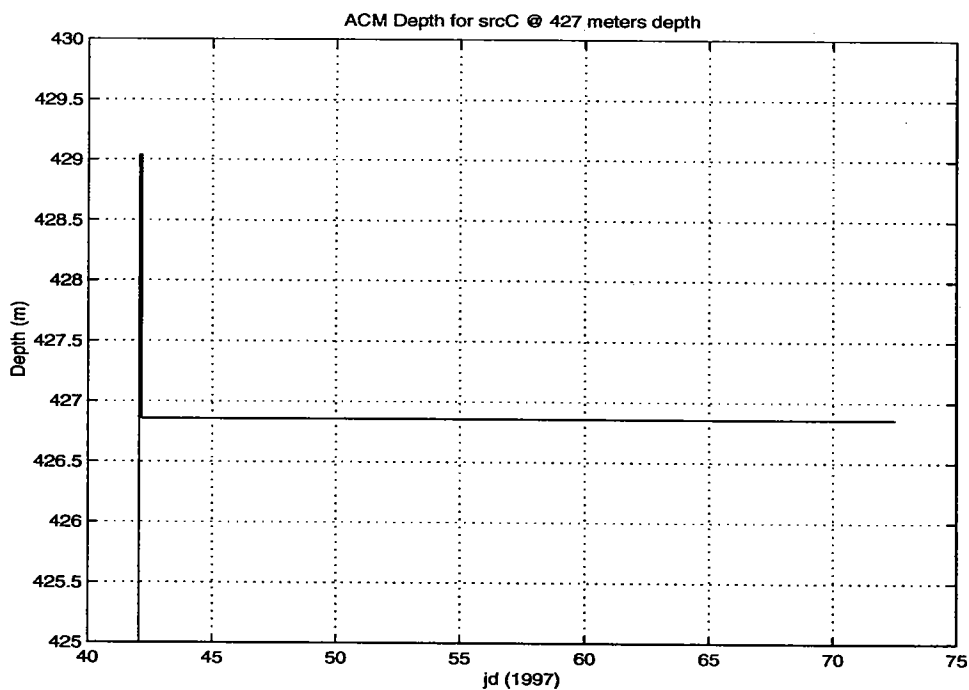


FIGURE 25. ACM depth for mooring C

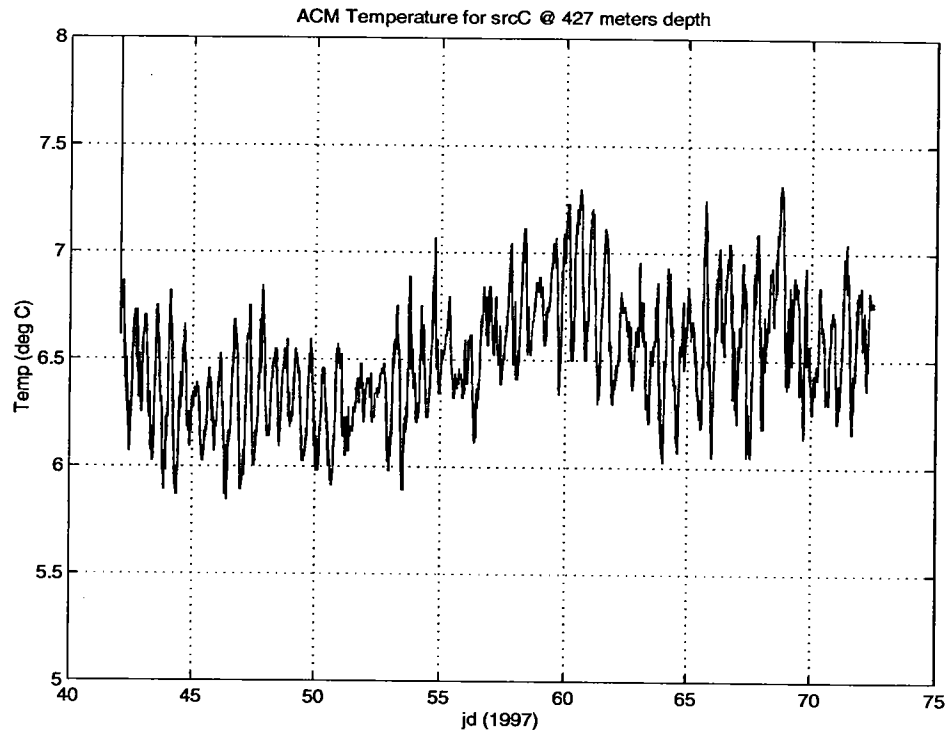


FIGURE 26. ACM temperature at 427 meters depth for mooring C

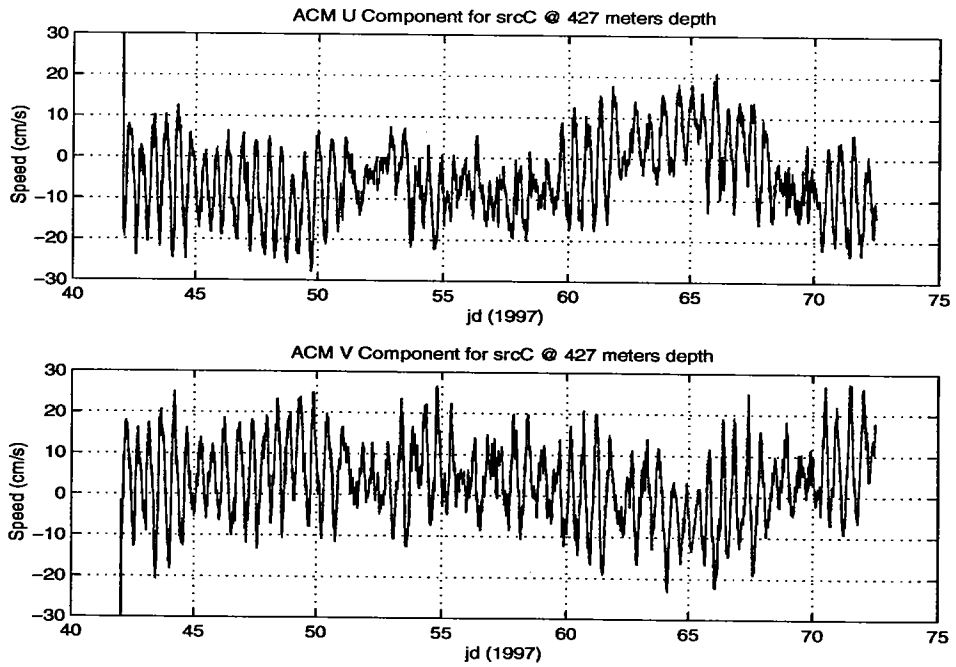


FIGURE 27. ACM U and V components at 427 meters depth at mooring C

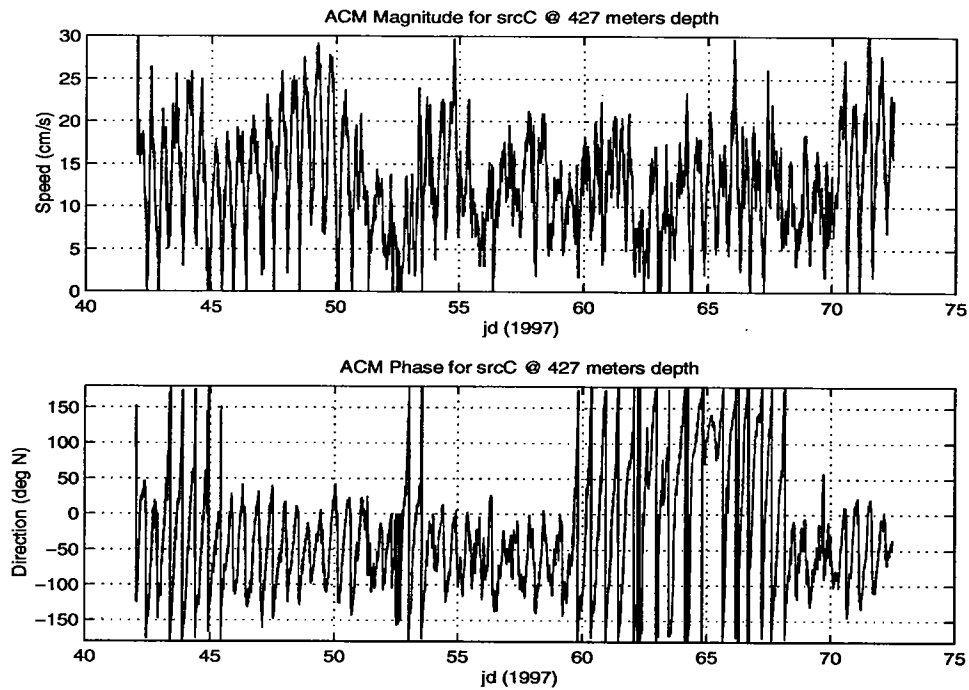


FIGURE 28. ACM magnitude and phase at 427 meters depth at mooring C

2.6.3 “SE” 400 Hz source and short array mooring

Like the other 400 Hz sites, the SE mooring contained a 400 Hz phase encoded source and a short 8 element hydrophone array. Initially, the source was scheduled to have a 70 sequence transmission but instead it used the same 48 sequence transmission that was used previously during Primer3. At recovery, the source was not transmitting due to a leak at the transducer. This failure happened sometime after deployment but the time of failure is unknown at this time. Post-cruise time checks are not available due to this failure.

Using the mooring dimensions and known depth at deployment, the ACM depth should be 247 meters. However, the pressure sensor on the ACM has an average depth of 286 meters (fig 29) which is below the bottom. Given this failure and the failure of the SW mooring ACM, it seems that the ACM pressure sensors cannot be trusted so the depth will be calculated using the mooring diagram (appendix 6.2). Temperature from the ACM can be used (fig 30). The U component of ACM current measurement failed to register negative values (fig 31). Multiple tpods were strapped to the mooring at numerous depths (table 22). Tpod sensors show a clear, deep M2 internal tide signal.(figs 32, 33). Since one of the tpods was strapped to the ACM, a comparison shows that both sensors are calibrated correctly (fig 34).

TABLE 19. SE mooring

| | |
|-------------|-----------------------|
| system | 013 |
| array | 010 |
| deployed | 2/10/97 0414 (Z) |
| recovered | 2/26/97 0630 (Z) |
| latitude N | 39 59.9956 (surveyed) |
| longitude W | 70 44.4883 (surveyed) |
| water depth | 279 meters |

TABLE 20. SE mooring hydrophone array #010 locations

| Depth (m) | phone - channel |
|-----------|-----------------|
| 259 | phone #1 - A |
| 256.90 | phone #2 - A |
| 257.13 | phone #3 - A |
| 257.33 | phone #1 - B |
| 255.05 | phone #4 - A |
| 255.25 | phone #2 - B |
| 255.45 | phone #3 - B |
| 253.38 | phone #4 - B |

TABLE 21. SE mooring Aanderra current meter

| Depth (m) | Serial number | starting time | sampling interval |
|-----------|---------------|------------------|-------------------|
| 247 | 9445 | Feb 3 @ 1700 hrs | 5 minutes |

TABLE 22. SE mooring temperature sensors

| Depth (m) | Serial number |
|-----------|---------------|
| 1 | 283 |
| 100 | 285 |
| 200 | 290 |
| 247 | 291 |
| 275 | 294 |

TABLE 23. Sys 013 - SE source mooring transmission schedule

| | |
|--|---|
| system time (pre-deployment) | day 37 17 51 14 |
| UTC time | day 37 17 51 14.000017 |
| source depth (meters) | 257 |
| transmission times (minutes after hour) | 6,26,46 |
| center frequency (Hz) | 400 |
| cycles per digit | 4 |
| digits per sequence | 511 (10 msec) |
| number of sequences transmitted | 70 (scheduled) 48 (actual) |
| sequence length | 7128 |
| M-seq law | 1175 (octal) |
| reception times (minutes after hour) | 1, 3, 13, 15, 21, 23, 33, 35, 41, 43, 53, 55 |
| number of sequences coherently averaged | n/a |

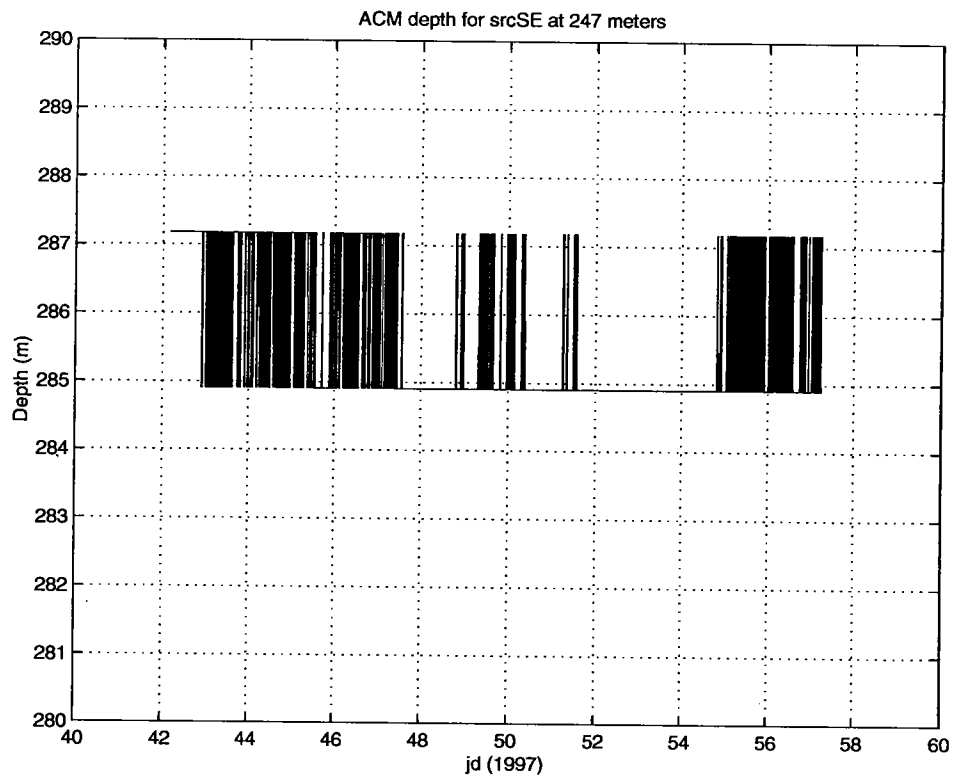


FIGURE 29. ACM depth sensor at 247 meters for mooring SE

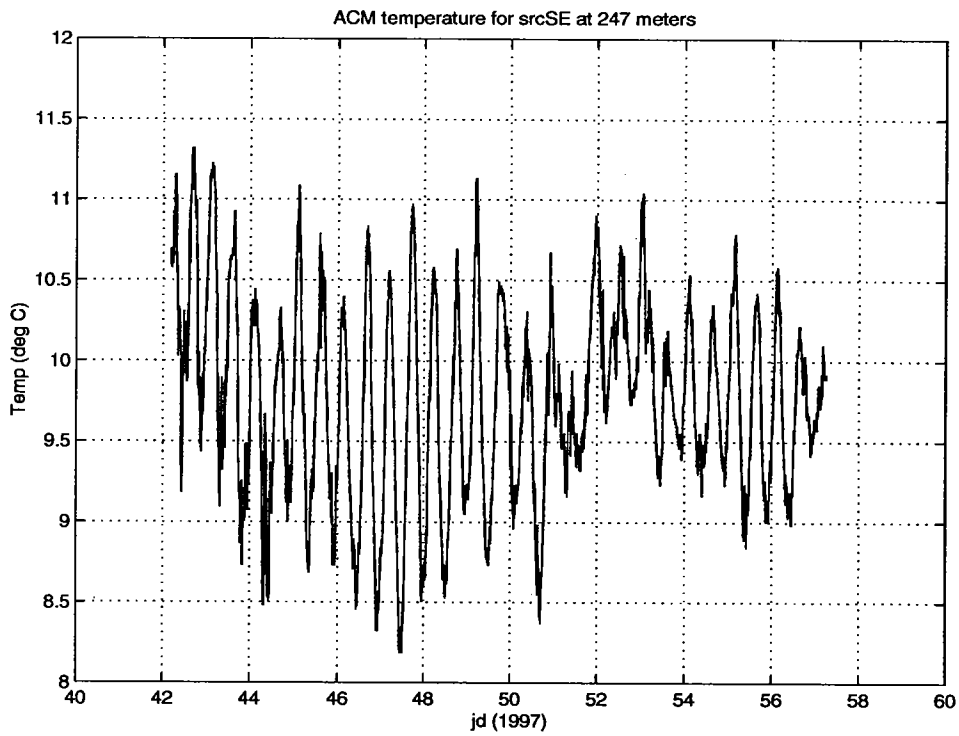


FIGURE 30. ACM temperature at 247 meters depth for mooring SE

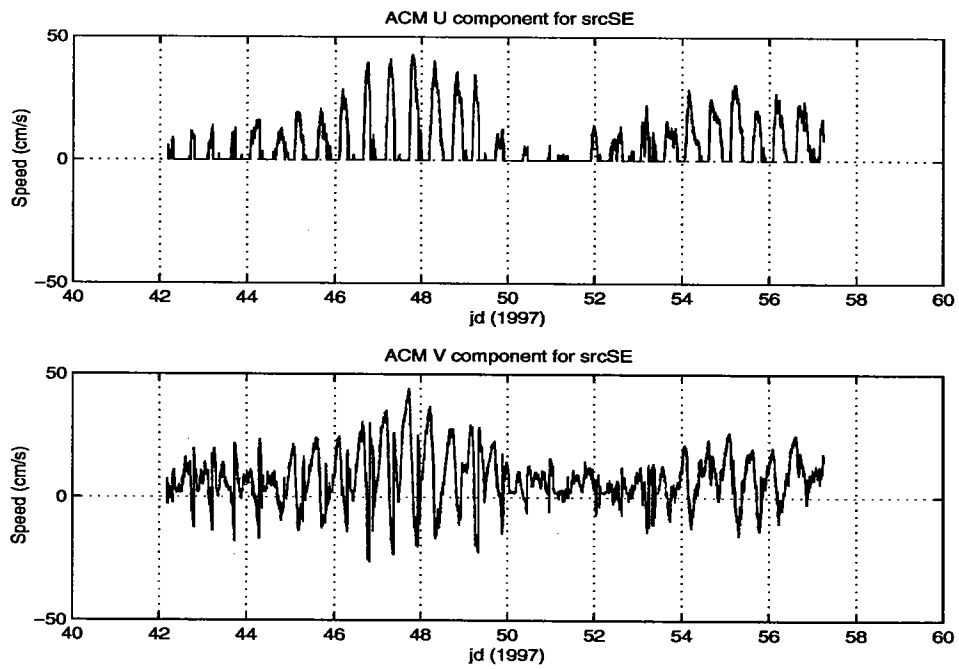


FIGURE 31. ACM U,V components at 247 meters depth for mooring SE

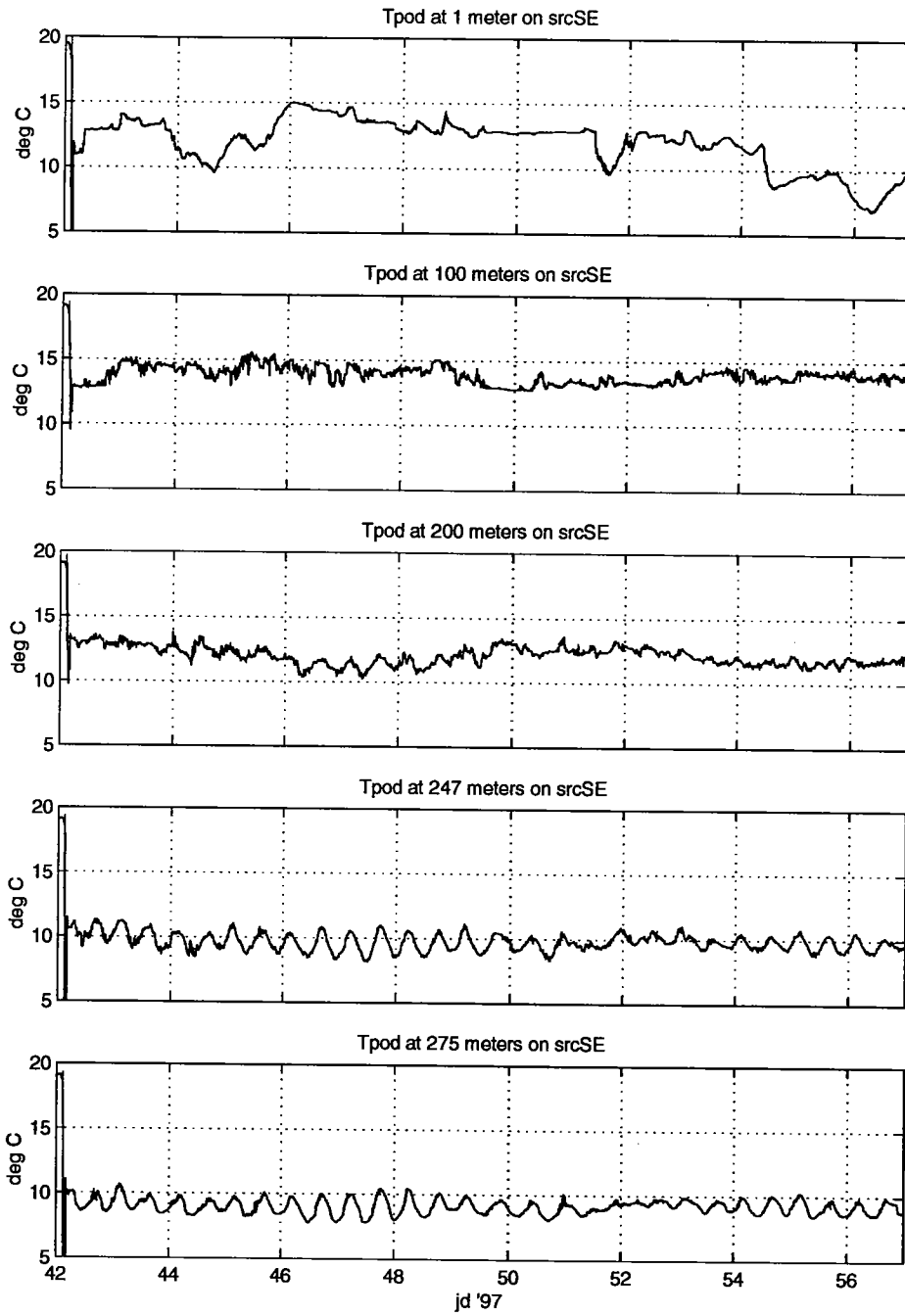


FIGURE 32. Tpod temperature sensors on mooring SE

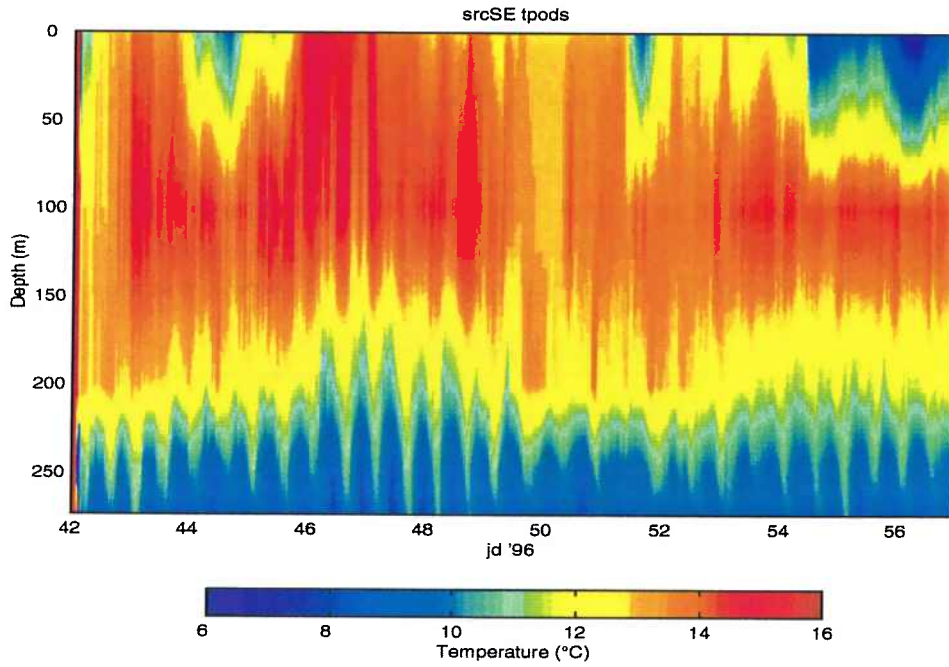


FIGURE 33. All tpod sensors on mooring SE

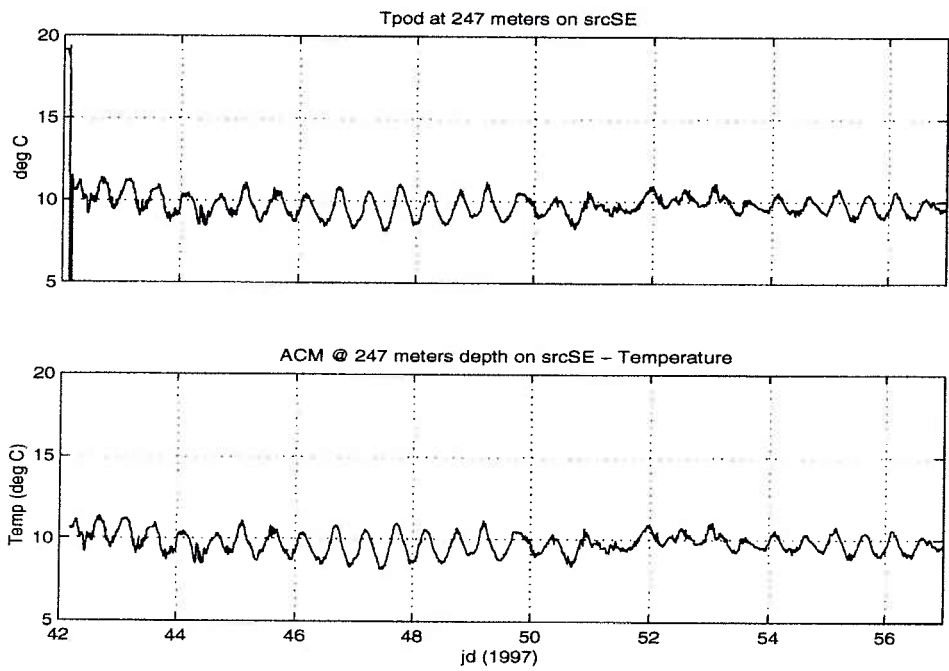


FIGURE 34. Comparison of temperature from tpod and ACM at same depth for SE mooring

2.6.4 224 Hz source mooring

To compare multiple frequency propagation along the same paths, a 224 Hz phase encoded Webb source was positioned near the SW 400 Hz source site. As in many experiments before, this source performed flawlessly. The internal clock for the 224 Hz source was inadvertently started 10 seconds too soon, thus making all scheduled transmissions 10 seconds early. Later in the cruise, the surface float at this site disappeared along with Seamon tpod #256, probably cut by a fishing vessel. Since the temperature sensor #7050 data didn't seem to span the entire deployment (fig 35), a closer look was necessary. When compared to the close 400 Hz SW source mooring, there seems to be a 1 day dropout on Feb 27th, day 56.25 (fig36). This temperature data will need more attention at a later date.

TABLE 24. 224 Hz Source "Bertha"

| | |
|-------------|-------------------------|
| deployed | 2/10/97 |
| recovered | 7/19/97 (summer pickup) |
| latitude N | 40 00.036036 (surveyed) |
| longitude W | 71 09.67715 (surveyed) |
| depth (m) | 282 |

TABLE 25. "Bertha" transmission schedule

| | |
|---|---|
| system time (pre-deployment) | day 41 11 24 00 |
| UTC time | day 41 11 24 59.999512 |
| source depth (meters) | 277 |
| transmission times (minutes after hour) | 0,5,10,... every 5 minutes (with 10 sec error) |
| center frequency (Hz) | 224 |
| cycles per digit | 14 |
| digits per sequence | 63 |
| number of sequences transmitted | 30 (3.9375 sec total) |
| sequence length | 5493 |
| M-seq law | 0103 (octal) |
| clock drift (sec) | .637986 |

TABLE 26. 224 Hz source mooring - temperature sensors

| depth (m) | sensor |
|-----------|------------------|
| 1 | #256 tpod (lost) |
| 270.5 | #7050 Brankner |

TABLE 27. Recovery time checks

| Grey Sailclock day hr min sec | Blue Sailclock day hr min sec | System Time day hr min sec |
|----------------------------------|----------------------------------|-------------------------------|
| 211 11 49 49.361526 | 211 11 49 50.401714 | 211 11 50 00 |
| 211 11 54 49.361158 | 211 11 54 50.401707 | 211 11 55 00 |

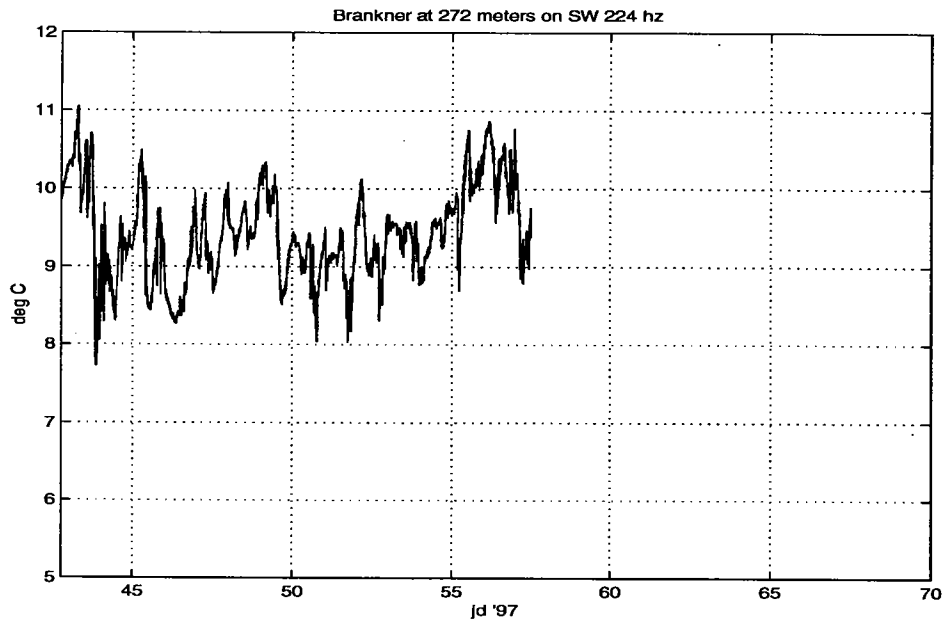


FIGURE 35. Brankner temperature sensor at 272 meters depth on 'Bertha'

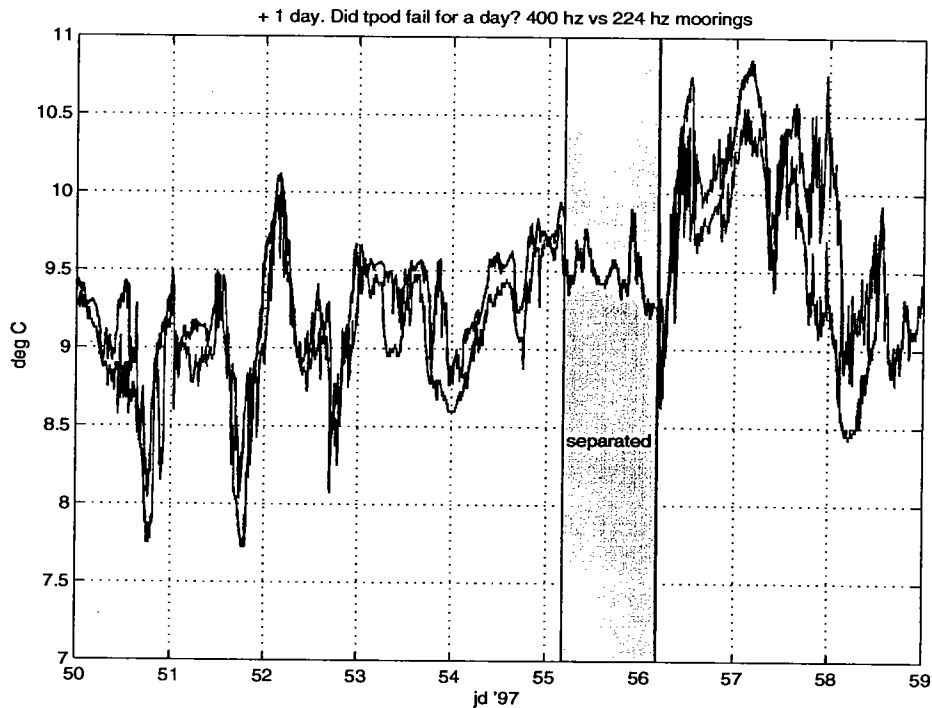


FIGURE 36. Comparison of temperature sensors at same depth for Bertha and mooring SW shows a 1 day failure for the Brankner sensor.

2.7 Acoustic receiver vertical and horizontal line arrays

Line hydrophone arrays were deployed in the Northwest and Northeast corners of the Primer4 area of study (fig 2). Sensor spacing was chosen to adequately sample the modal propagation field. The WHOI VLA in the northwest corner had a surface mooring for telemetry capabilities in addition to internal storage of data while the “Shark of Science” VLA in the northeast corner only internally recorded data (see appendix 6.1).

Ocean acoustic tomography requires very accurate measurements of range between source and receiver for determining changes in arrival times. Without accurate positioning, mooring tilt, due to currents and tides, could be confused as an oceanographic feature by altering range, and thus travel time, between source and receiver. All data needs to be corrected for the effects of mooring motion before subsequent processing can proceed. To navigate the WHOI Vertical Line Array, 3 Benthos transponders were positioned on the seafloor at approximately 1 km from the mooring’s anchor forming a triangle surrounding the mooring. The transponders were also positioned at slightly different distances from the mooring so that the acoustic responses would not interfere with each other. Two hydrophones on the WVLA and an independent navigator attached to the mooring were used for recording the position navigation receptions.

2.7.1 WHOI Vertical Line Array (WVLA)

Temperature sensors were strapped on the WHOI VLA at critical depths to sample the water column temperature field (figs 37 38).

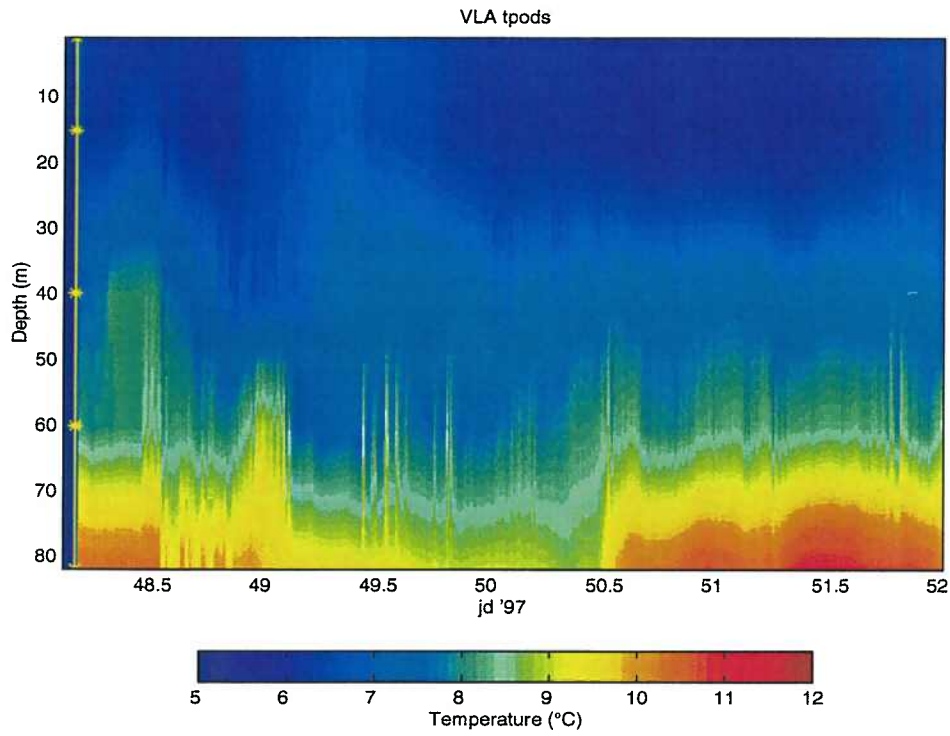


FIGURE 37. VLA tpod temperature sensors

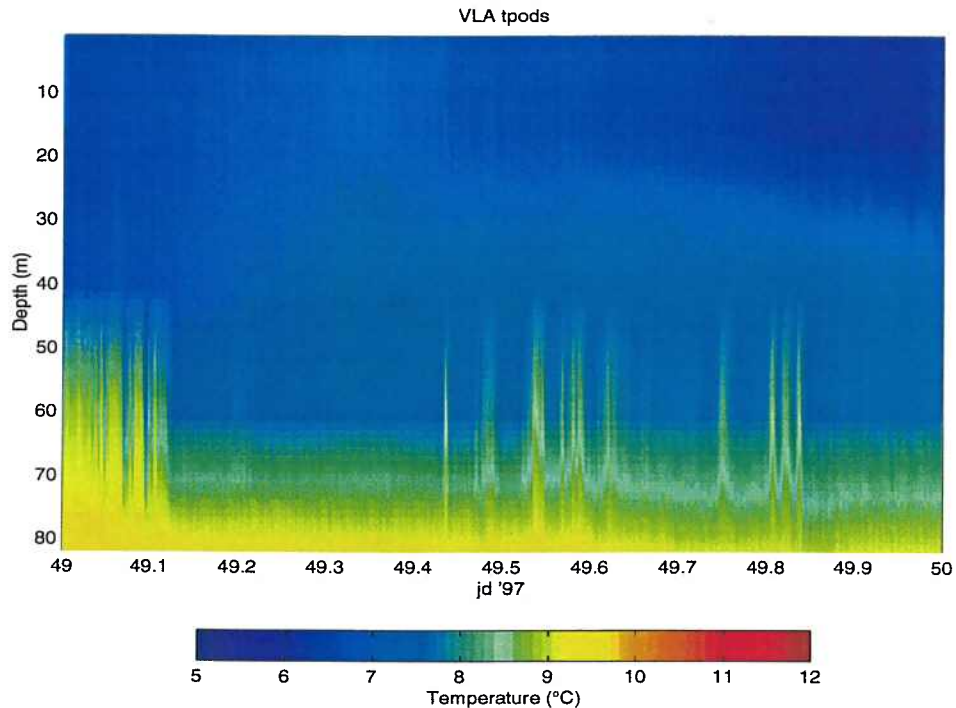


FIGURE 38. Blowup of VLA tpods to show 1 day and internal wave activity

The WVLA was deployed in the same approximate location as it had been during the previous summer's Primer3 experiment to reuse the transponders for determining mooring motion that were left there previously. They were resurveyed and it was found that the 12.5 kHz transponder was missing. An 11.5 kHz transponder was deployed in its place. The frequency change was necessary so that there would be no interference if the missing 12.5 kHz transponder unexpectedly became active again.

The day before departure from port the hydrophone array was again tested for reliability. Much to everyone's surprise, the array failed. The termination to the electronic package was refitted but still failed to work. An older array once deployed in the Barents Sea was used instead. The alternate hydrophone array was designed for deeper water so the length and spacing on this array was longer. Instead of having 3.3 meter hydrophone spacing and spanning 30 meters vertically, the array had 10 meter spacing and spanned 150 meters. To fit it for shallower water, the hydrophone in the center of the array was removed and the termination to the electronics package was made there. Spatial sampling of the water column was now more coarse than originally intended but this design added another feature, an 8 element horizontal array. All phones worked after deployment; however a few failed within a couple of days probably due to the strain from bad weather (fig 39). The horizontal array ran approximately 90 degrees West (fig 40) from the anchor.



FIGURE 39. Large wave ready to break over the fantail.

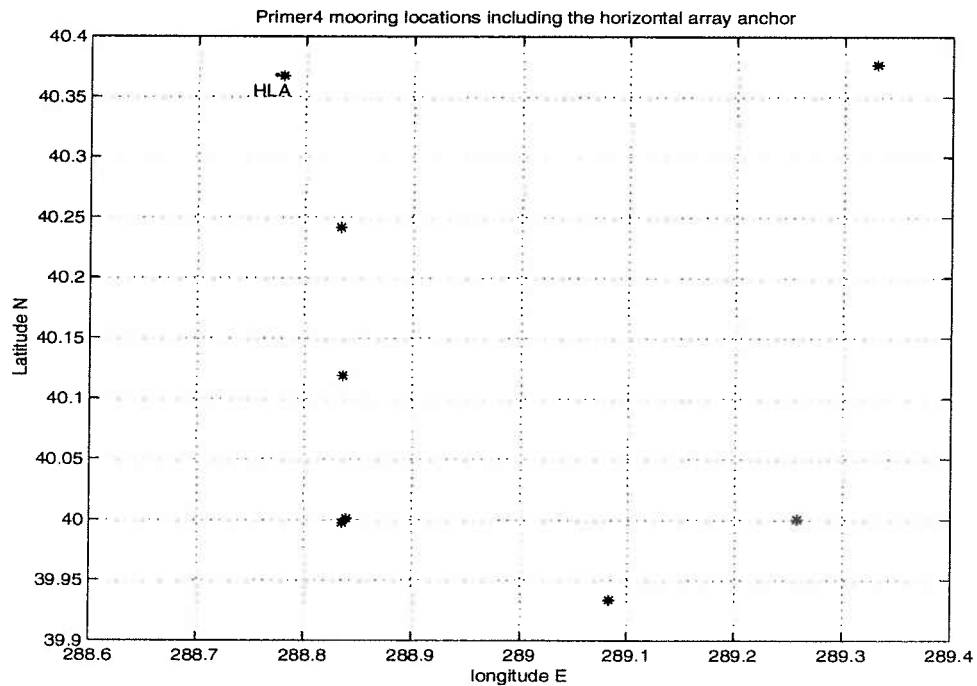


FIGURE 40. Horizontal hydrophone array positions

WVLA phones 0 and 6 were used for taking mooring navigation data at times when the sources were quiet, but that data was very sporadic and thus not useful. An external navigator was also used (fig 41). One channel was very noisy but the other two channels are good enough to use for navigation.

Problems with the array started as time went on and the weather deteriorated. All hydrophones worked after deployment on Feb. 17, but by Feb 19, only 2, 10, and 12 seemed to be still functioning properly.

Channel 2 of the VLA worked consistently throughout the experiment. Three datafiles were chosen for spectral analysis. The datafile on Feb 27 at 0646 hours (GMT) was the first full file just after deployment. Source arrivals are easily seen in a spectrogram of channel 2 of this datafile (fig 42). The 224 Hz and 400 Hz sources are evident as well as a bit of low frequency broadband ship noise. Also notice that only 2 of the 400 Hz sources were working leaving a gap after 2 consecutive responses. 400 Hz source at the Central mooring which was scheduled to "sing" at 6, 26 and 46 minutes past the hour did not transmit any sound. The spectrum of record 267 (fig 43) for unprocessed (raw) data shows the 244 Hz source well above (20 dB maximum) the noise level. All hydrophones were working at this time (figs 44, 45, 46, 47).

Spectrogram of channel 2 of the VLA datafile on Feb 29 at 2001 (GMT) (fig 48) shows a clear signal of the 400 and 224 Hz sources with some low frequency noise. Since the propagation path of the source at mooring SE was longer than the moorings at the SW corner, some of the signal is lost in the noise. At this time some of the degradation of hydrophones 0,1,3,4,5,6,8,9,11,13,14, and 15 has started (figs 49 - 52). Only channels 2, 12, and possibly 10 show no wear. Recall that the weather was becoming extremely violent, which was probably the reason for the degradation of the hydrophones.

The datafile on Feb 22 at 1030 hours contained data near the end of the deployment. Although the sources were still operating at this time, source levels can barely be seen above the noise (fig 53). Also notice that some of the hydrophones that previously were noisy probably have some usable data (figs 54-57). Phones 0, 2,10,11, and 12 in particular look good.

TABLE 28. WHOI VLA

| | |
|-------------------|-----------------------|
| deployed | 2/17/97 0445 (Z) |
| recovered | 2/22/97 0200 (Z) |
| latitude (array) | 40 22.0848 (surveyed) |
| longitude (array) | 71 13.7329 (surveyed) |
| water depth | 83 meters |

TABLE 29. WHOI VLA temperature sensors

| Depth (m) | Serial number |
|-----------|---------------------|
| 1 | 953 (high flyer) |
| 1 | 952 (buoy) |
| 15 | 7045 |
| 25 | 7047 (Did not work) |
| 40 | 7044 |
| 60 | 7052 |
| 82 | 310 |

TABLE 30. WHOI VLA external navigator

| | |
|--------------------|-------------------------|
| navigator | # 010 @ 28 meters depth |
| transponder depths | 83 meters |

TABLE 31. WHOI VLA navigator locations

| transponder frequency | latitude (surveyed) | longitude (surveyed) |
|-----------------------|---------------------|----------------------|
| 11.0 kHz | 40 22.2948 | 71 13.5401 (1996) |
| 12.0 kHz | 40 21.9316 | 71 13.7797 |
| 11.5 kHz | 40 22.2332 | 71 13.5882 |

TABLE 32. WHOI VLA hydrophone spacing

| Depth (m) | phone number | status at end |
|-----------|-----------------------|---------------|
| 20 | 0 (navigation phone) | intermittent |
| 30 | 1 | noisy |
| 40 | 2 (navigation phone) | good |
| 50 | 3 | bad |
| 60 | 4 | intermittent |
| 70 | 5 | bad |
| 80 | 6 (navigation phone) | intermittent |
| not used | 7 | break out |
| 83 | 8 (7 m from anchor) | bad |
| 83 | 9 (17 m from anchor) | bad |
| 83 | 10 (27 m from anchor) | noisy |
| 83 | 11 (37 m from anchor) | intermittent |
| 83 | 12 (47 m from anchor) | good |

TABLE 32. WHOI VLA hydrophone spacing

| Depth (m) | phone number | status at end |
|-----------|-----------------------|---------------|
| 83 | 13 (57 m from anchor) | bad |
| 83 | 14 (67 m from anchor) | bad |
| 83 | 15 (77 m from anchor) | bad |

TABLE 33. Datafile status for VLA tape #00

| date time | size (bytes) | # of recs |
|-------------|--------------|-----------|
| tape header | 1024 | 1 |
| 02170157 | 16,793,600 | 16 |
| 02170236 | 6,297,600 | 6 |
| 02170529 | 192,076,600 | 183 |
| 02170642 | 6,297,600 | 6 |
| 02170646 | 314,880,000 | 300 |
| 02170843 | 263,449,600 | 251 |
| 02191606 | 314,880,000 | 300 |
| 02191803 | 314,880,000 | 300 |
| 02192001 | 314,880,000 | 300 |
| 02192158 | 81,068,800 | 78 |
| 02192356 | 314,880,000 | 300 |
| 02200026 | 314,880,000 | 300 |
| 02200224 | 314,880,000 | 300 |
| 02200421 | 314,880,000 | 300 |
| 02200619 | 314,880,000 | 300 |
| 02200816 | 314,880,000 | 300 |
| 02201014 | 314,880,000 | 300 |
| 02201211 | 251,904,000 | 240 |

TABLE 34. Datafile status for WVLA tape #01

| date time | size (bytes) | # of recs |
|-------------|--------------|-----------|
| tape header | 1 kb | 1 |
| 02201345 | 314,880,000 | 300 |
| 02201543 | 314,880,000 | 300 |
| 02201740 | 314,880,000 | 300 |
| 02201938 | 314,880,000 | 300 |
| 02202135 | 314,880,000 | 300 |
| 02202333 | 314,880,000 | 300 |
| 02210130 | 251,904,000 | 240 |
| 02210304 | 210,969,600 | 201 |

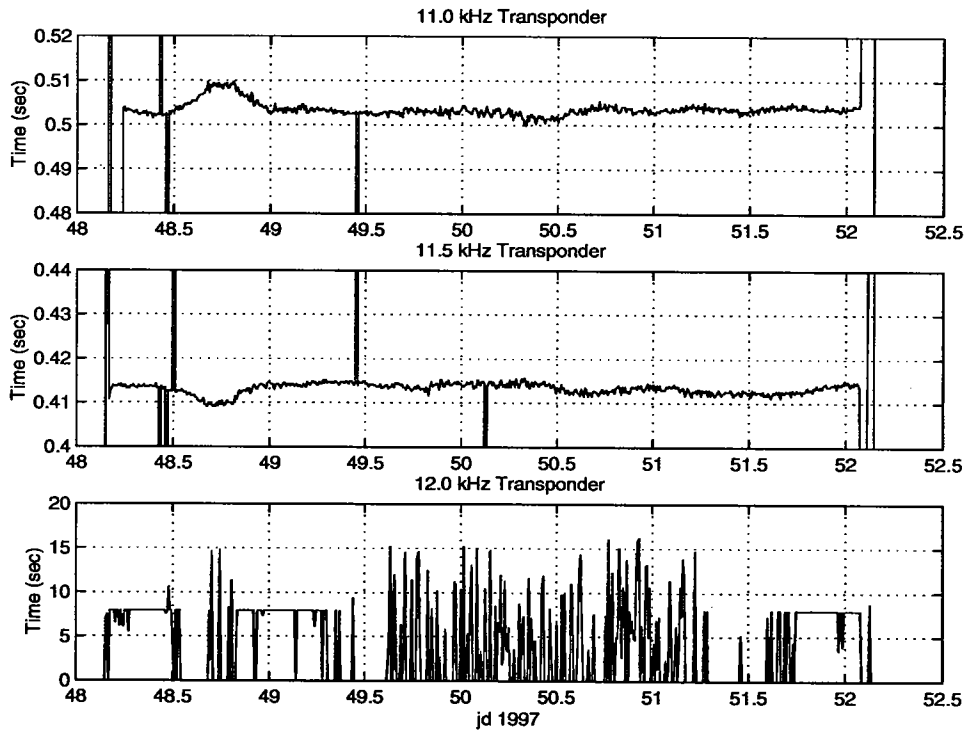


FIGURE 41. WHOI VLA navigator #10 travel times

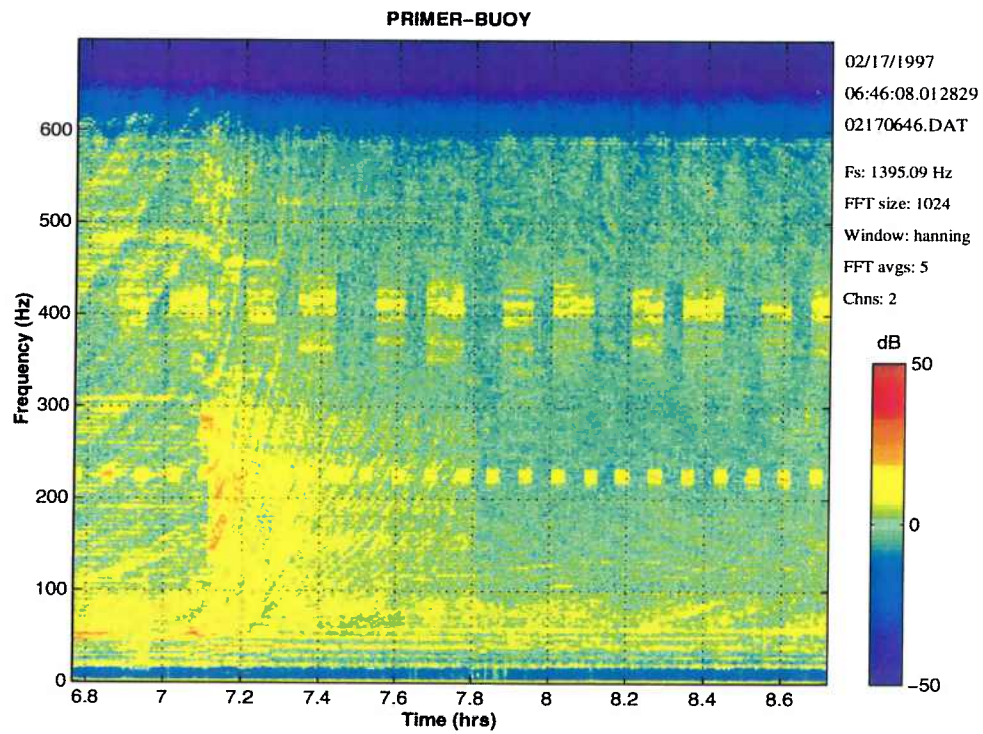


FIGURE 42. Frequency spectrum for all samples for start of experiment on 2/17 at 0646 from VLA

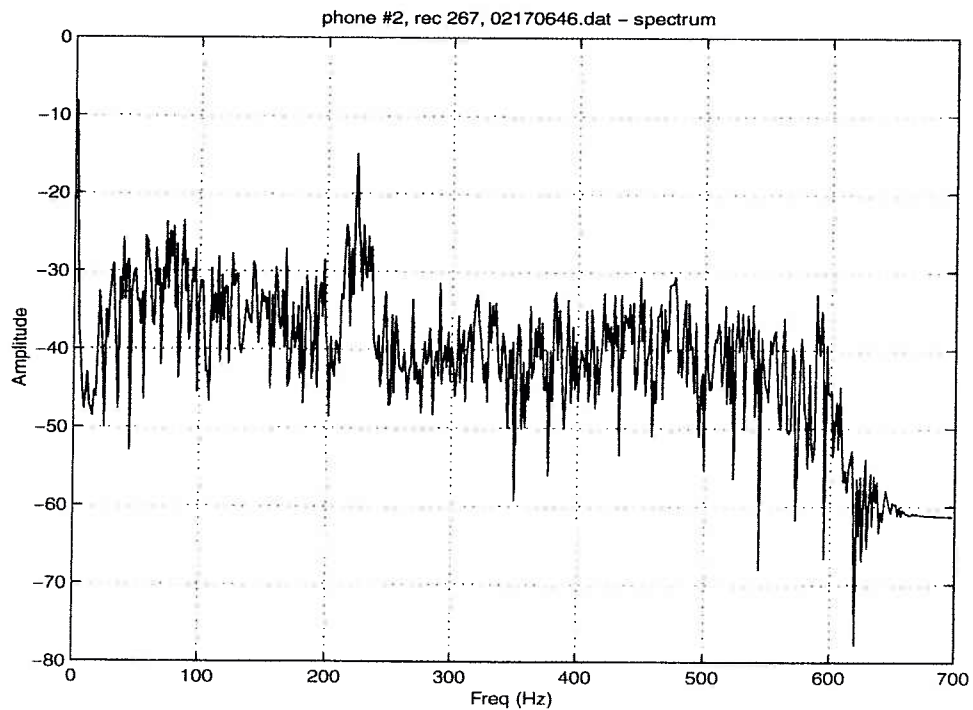


FIGURE 43. Frequency spectrum for phone #2 on 2/17 at 0646 showing 224 Hz signal from VLA

Primer4 – VLA Vertical Hydrophone Voltages – 02170646.dat, rec 267

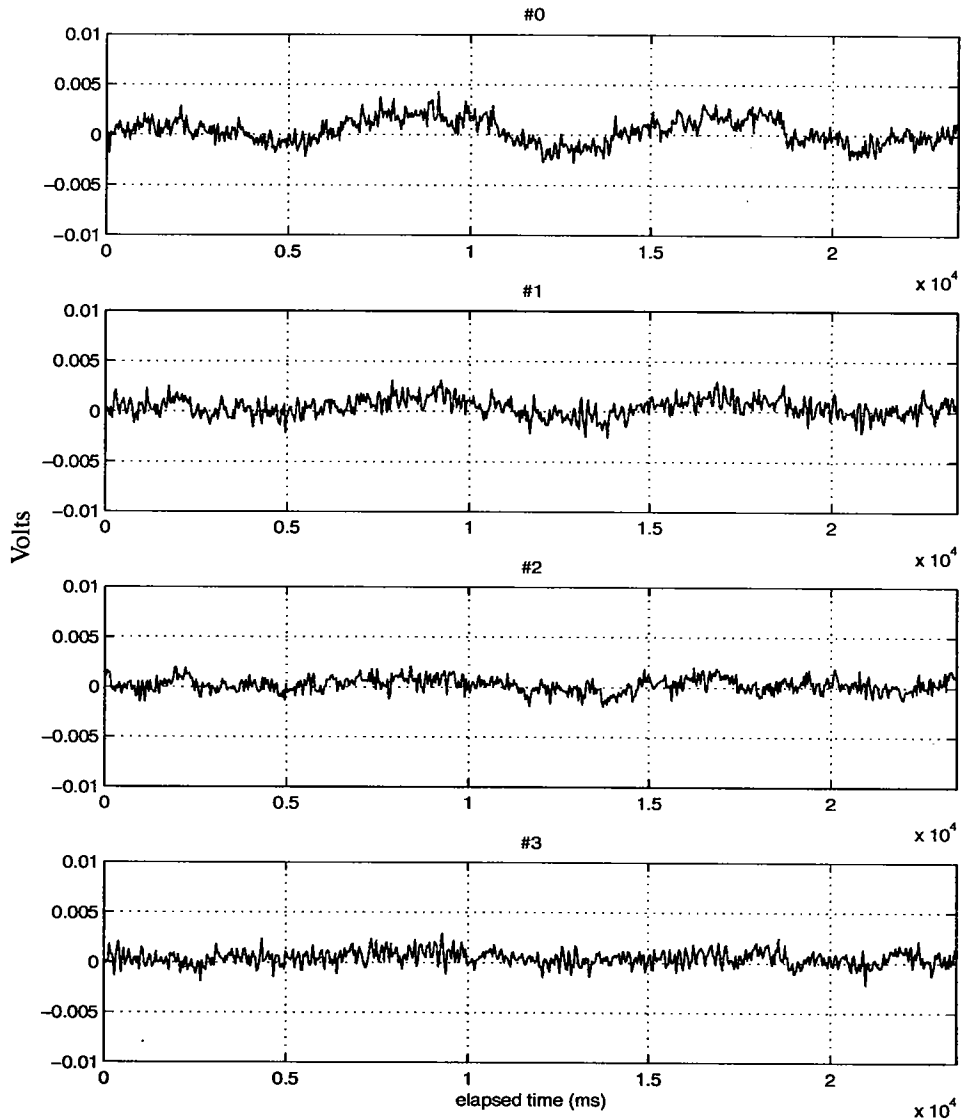


FIGURE 44. VLA vertical hydrophone voltages for phones 0-3, 2/17 at 0646, record number 267. Elapsed time is in milliseconds $\times 10^4$

Primer4 – VLA Vertical Hydrophone Voltages – 02170646.dat, rec 267

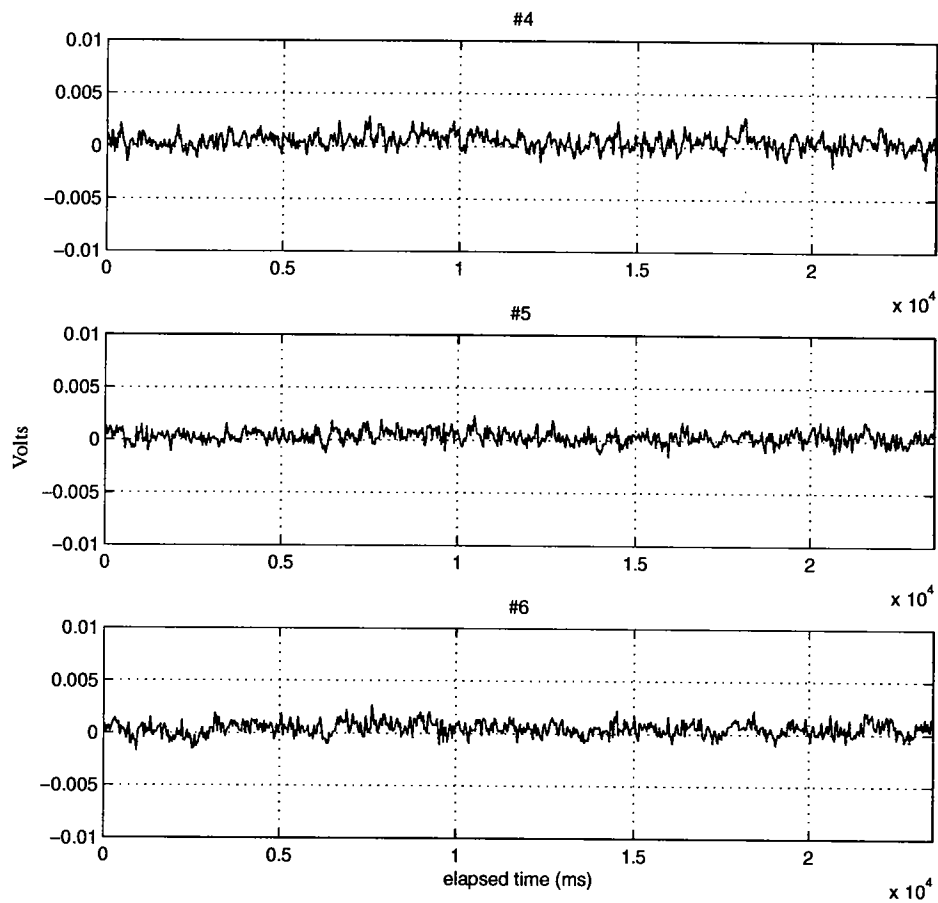


FIGURE 45. VLA vertical hydrophone voltages for phones 4-6, 2/17 at 0646, record number 267. Elapsed time is in milliseconds $\times 10^4$

Primer4 – VLA Horizontal Array Voltages – 02170646.dat, rec 267

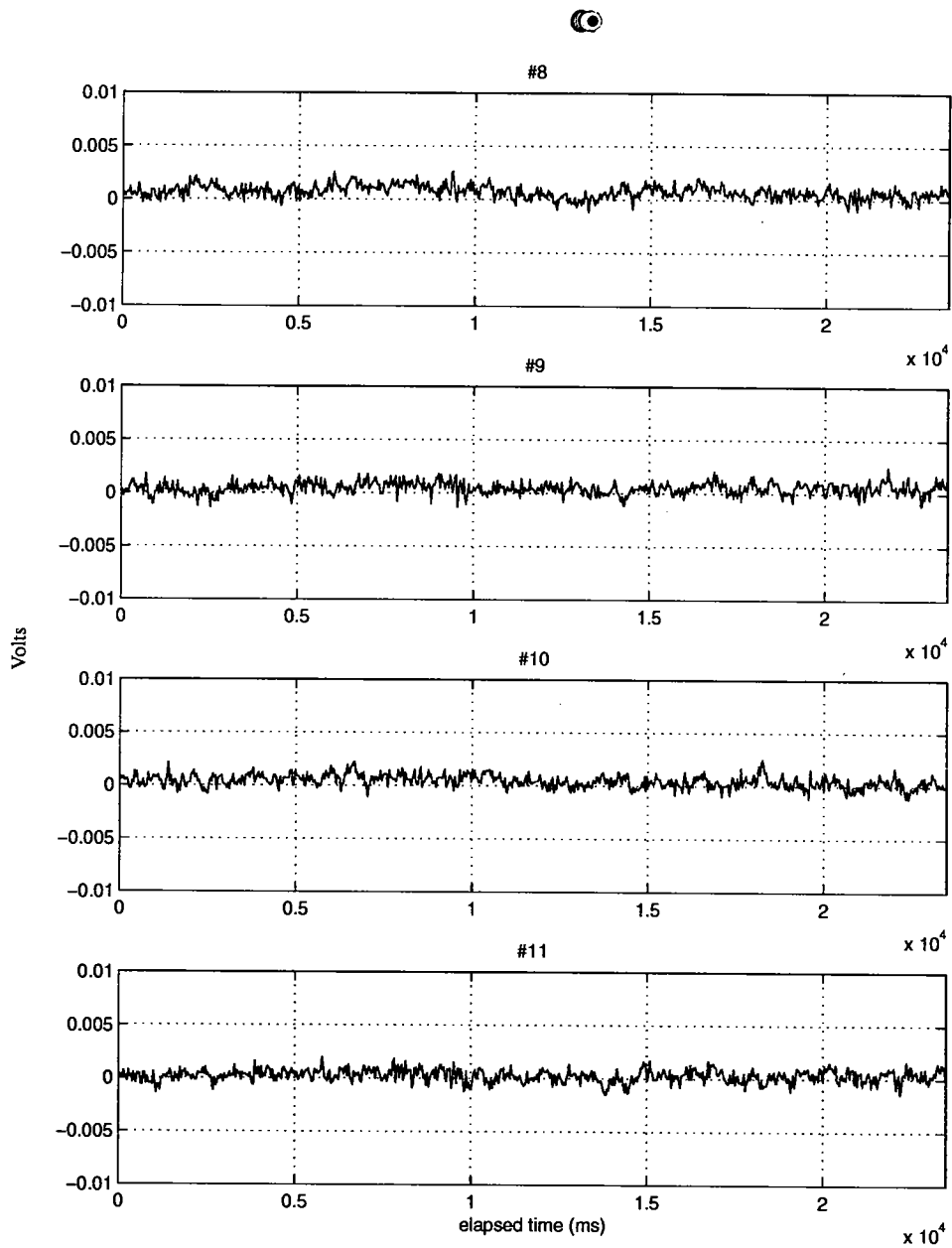


FIGURE 46. VLA horizontal hydrophone voltages for phones 8-11 on 2/17 at 0646, record 267. Elapsed time is in milliseconds $\times 10^4$.

Primer4 – VLA Horizontal Array Voltages – 02170646.dat, rec 267

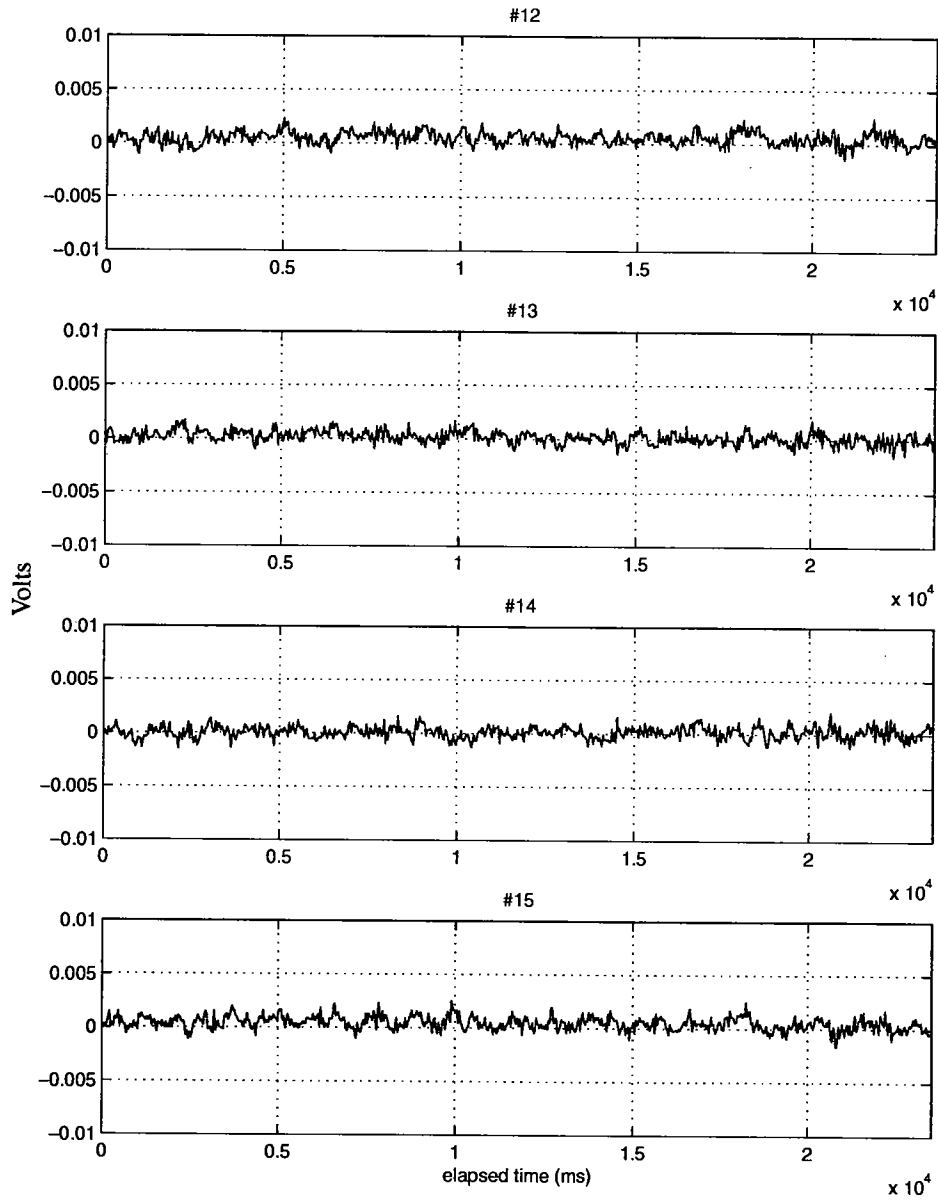


FIGURE 47. VLA horizontal hydrophone voltages for phones 12-15 on 2/17 at 0646, record 267. Elapsed time is in milliseconds $\times 10^4$.

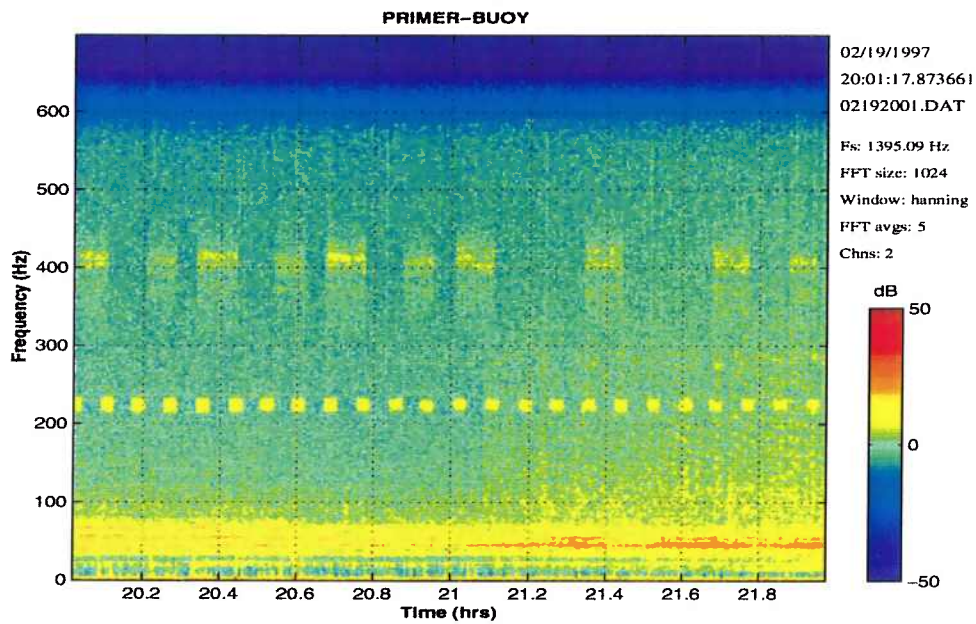


FIGURE 48. VLA channel #2 frequencies for 02/19 at 2001.

Primer4 – VLA Vertical Hydrophone Voltages – 02192001.dat, rec 1

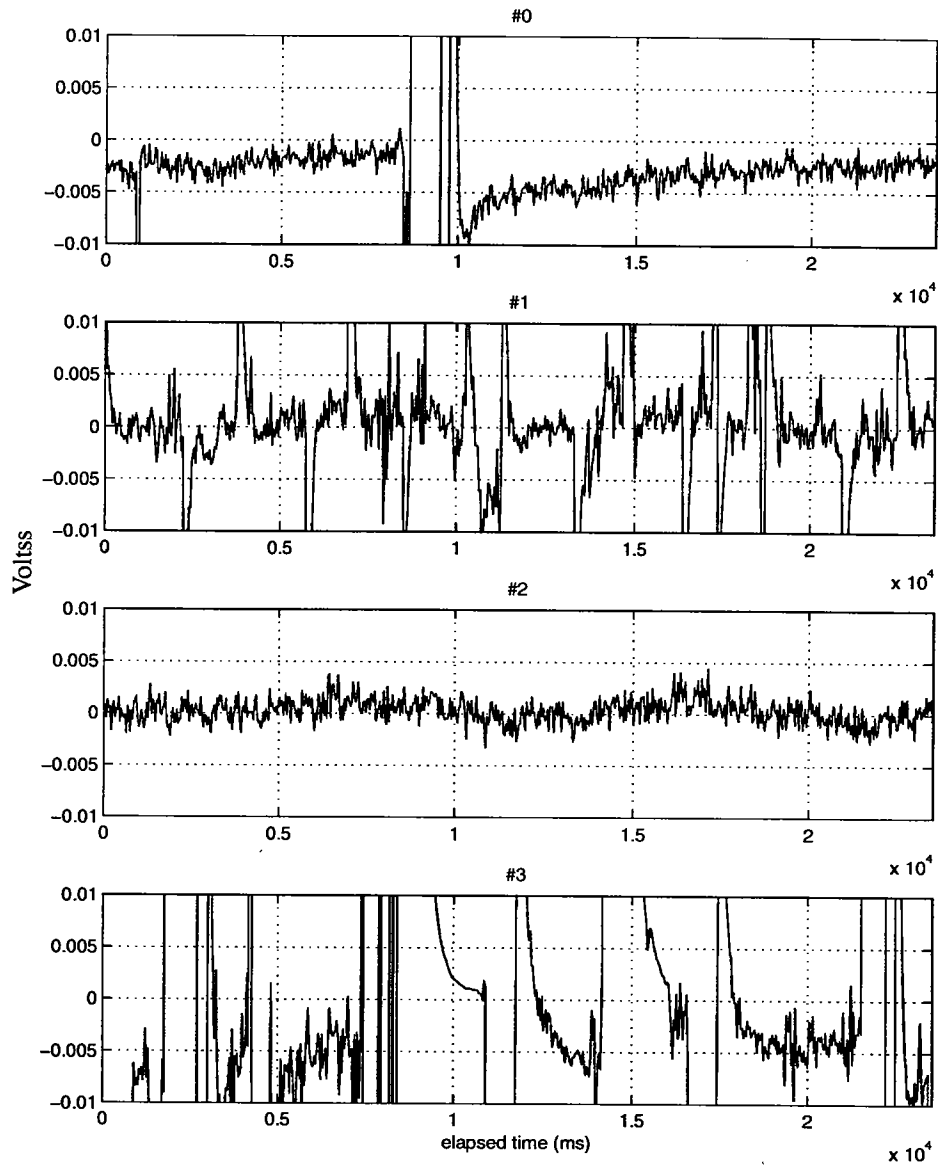


FIGURE 49. VLA vertical hydrophone voltages for phones 0-3 two days into experiment now showing problems. Only hydrophone #2 is unaffected. Elapsed time is in milliseconds $\times 10^4$.

Primer4 – VLA Vertical Hydrophone Voltages – 02192001.dat, rec 1

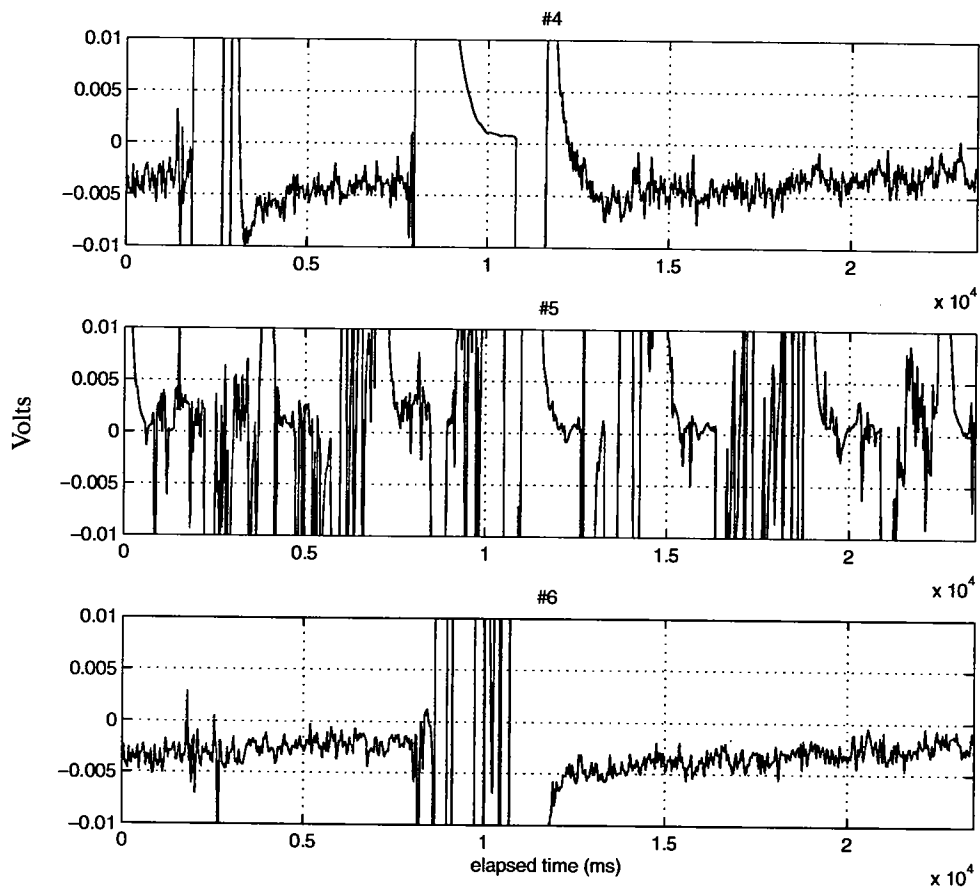


FIGURE 50. VLA vertical array hydrophones 4-6 two days into experiment now showing problems. Elapsed time is in milliseconds $\times 10^4$.

Primer4 – VLA Horizontal Array Voltages – 02192001.dat, rec 1

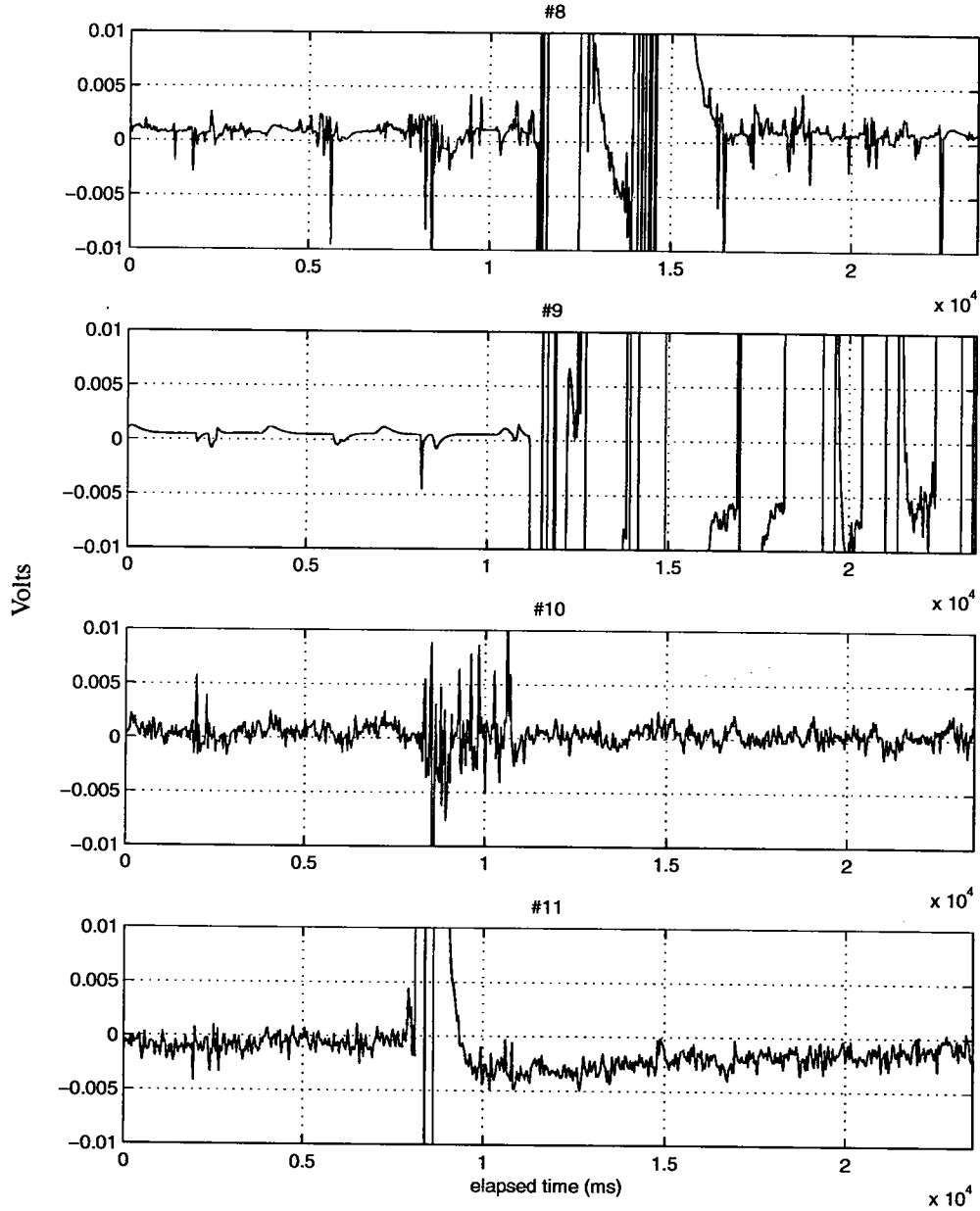


FIGURE 51. VLA horizontal array hydrophones 8-11 two days into experiment now showing problems. Elapsed time is in milliseconds $\times 10^4$.

Primer4 – VLA Horizontal Array Voltages – 02192001.dat, rec 1

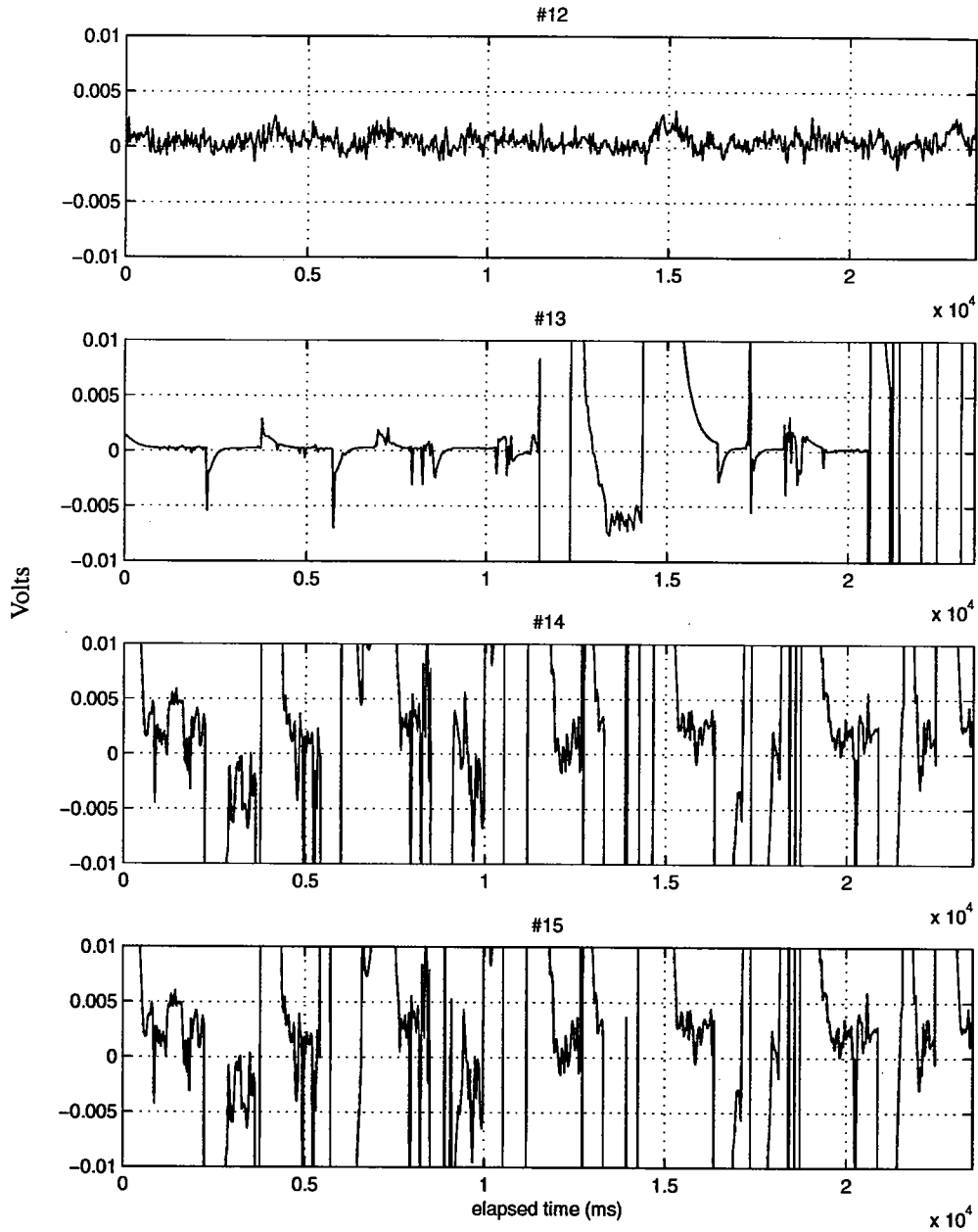


FIGURE 52. VLA horizontal array hydrophones 12-15 two days into experiment now showing problems. Only hydrophone #12 is unaffected. Elapsed time is in milliseconds $\times 10^4$.

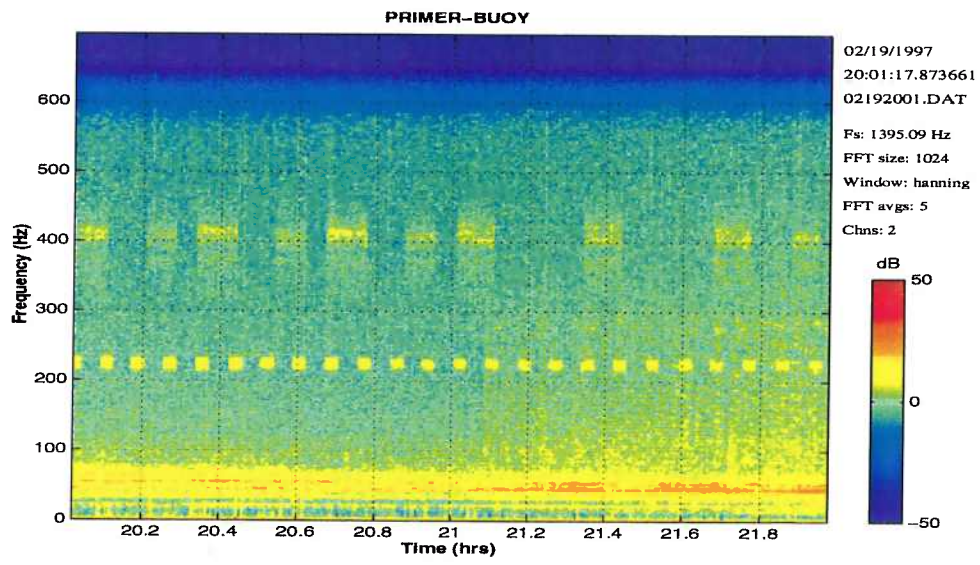


FIGURE 53. VLA frequency spectrum for channel #2 at end of experiment.

Primer4 – VLA Vertical Hydrophone Voltages – 02202333.dat, rec 100

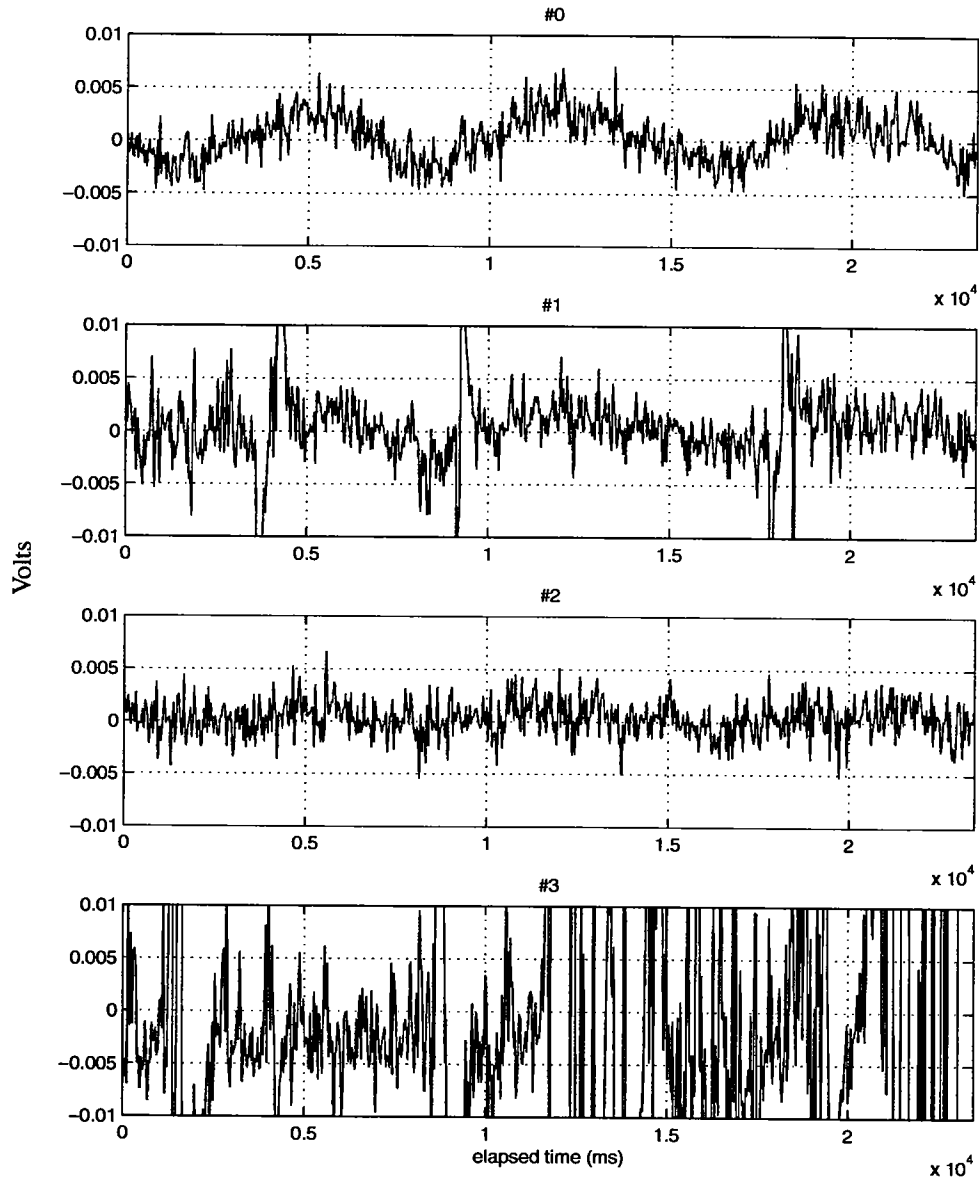


FIGURE 54. VLA vertical array voltages for phones 0-3 at end of experiment. Elapsed time is in milliseconds $\times 10^4$.

Primer4 – VLA Vertical Hydrophone Voltages – 02202333.dat, rec 100

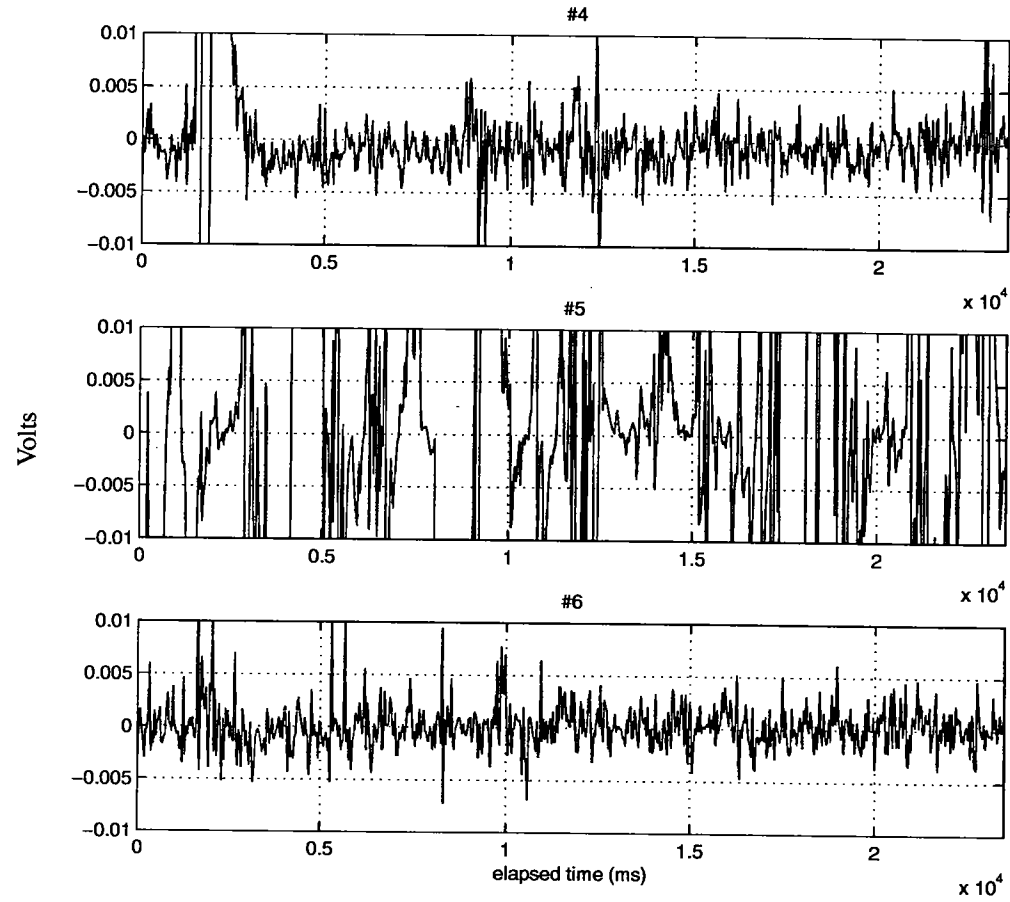


FIGURE 55. VLA vertical array voltages for phones 4-6 at end of experiment. Elapsed time is in milliseconds $\times 10^4$.

Primer4 - VLA Horizontal Array Voltages - 02202333.dat, rec 100

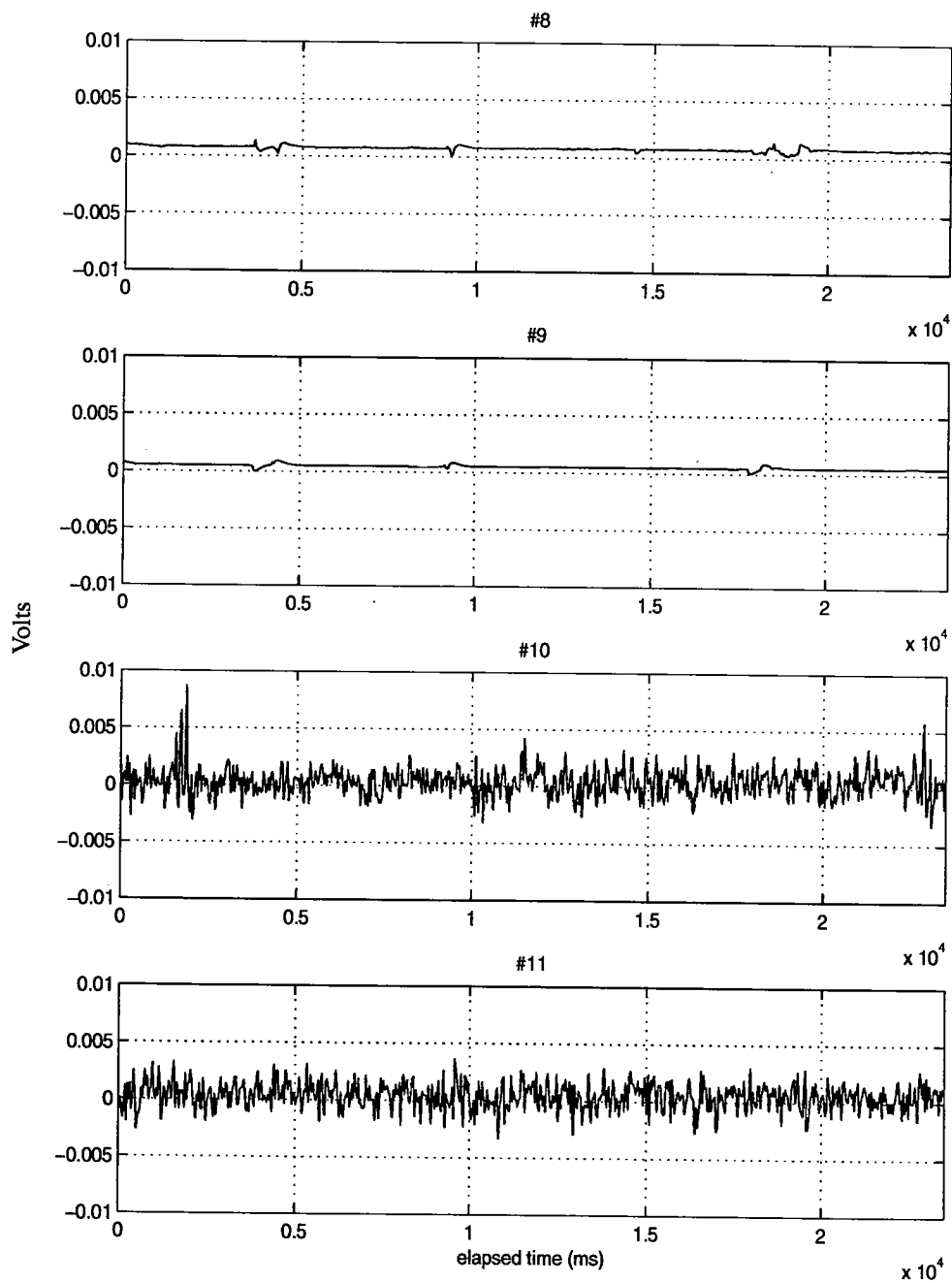


FIGURE 56. VLA horizontal array voltages for phones 8-11 at end of experiment. Elapsed time is in milliseconds x10⁴.

Primer4 – VLA Horizontal Array Voltages – 02202333.dat, rec 100

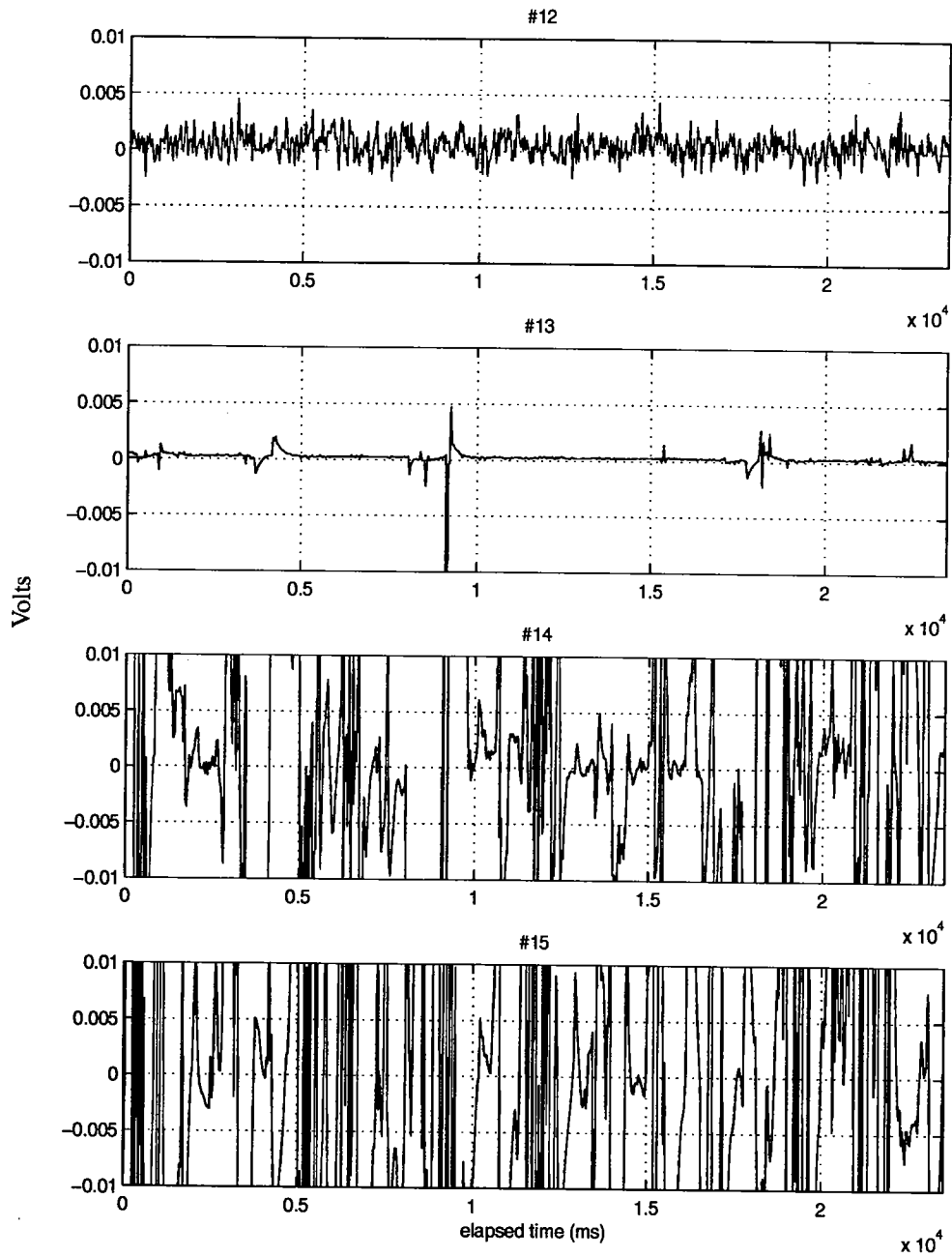


FIGURE 57. VLA horizontal array voltages for phones 12-15 at end of experiment. Elapsed time is in milliseconds $\times 10^4$.

2.7.2 “Shark of Science” vertical array



FIGURE 58. The “Shark of Science” anchor containing storage electronics.

The “Shark of Science” hydrophone array got its name from the shape of the array anchor/instrument sled. The mooring is U-shaped and contains two anchors 180 meters apart. One anchor was designed to hold the array electronics housing and also to be a vehicle which can “fly” through the water until it finds a suitable anchoring location (fig 58). The welder who assembled the vehicle thought it looked like a shark so he welded eyes and a sharp-toothed mouth onto the vehicle; thus “Shark of Science”.

All hydrophones on the Shark worked throughout the experiment. Shark was started on Feb 11 at 1600 hours. Datafile #1 contains pre-deployment test data that were taken on deck. The Shark anchor did not have an acoustic release, so the actual mooring location was not surveyed.

Note: Shark datafile header dates have wrong year, should be 1997, not 1996!

The signal to noise ratio was very good for all receptions by the Shark from the beginning of the experiment (fig 59) to the end (fig 61). The missing 400 Hz signal at 6 minutes after the hour from the Central source is evident in the data (fig 60). All phones also were recording at the end (fig 62,63,64,65).

The format of the internal VLA navigation data is a sequence of groups of 22 ASCII numbers. Each group represents the 2-way travel time measured from the WHOI pinger mounted on the sled, to each of the 3 Benthos transponders, and back to selected hydro-

phones on the vertical array. The data in each group establish the date, time, and travel time.

The ping duration from the WHOI pinger was 10 ms. The pinger fired 4 times at 5 second intervals starting at precisely the reported time. The intended timing of navigation “epochs” was every 5 minutes starting at 2 minutes after the hour. The sequence of events were:

- at the beginning of epoch, a pre-selected channel was applied to the detectors and the pinger was fired.
- the time of the first detection at each of 4 frequencies (3 transponder reply frequencies and the pinger frequency of 10.5 kHz) was noted until a 5 second window had elapsed.

No corrections have been made to accommodate detection latency or “turnaround” times in the Benthos transponders. The detectors in the VLAs have a detection delay of about 3 ms. The reported round trip traveltimes are in microseconds.

The numbers reported per navigation epoch are:
month day hour minute second microseconds

(10.5 to channelA) (11.0 to channelA) (11.5 to channelA) (12.0 to channelA)
(10.5 to channelB) (11.0 to channelB) (11.5 to channelB) (12.0 to channelB)

The internal navigation for both channels 0 and 6 show multipath jumps (figs 66, 67) most likely due to the foot of the front interacting with the paths. The external navigator was much higher on the mooring and doesn’t show the multipath effects (fig 68). One of the channels of the external navigator failed to work properly, but only two travel time arrivals are sufficient for performing localization. In previous shallow water experiments, localization was more sensitive to the water temperature than the 2-way travel time so the navigation data was not used for localization in these cases. Fortunately, the moorings are rigid enough to prevent large off-center excursions.

TABLE 35. “Shark of Science” VLA

| | |
|-------------|----------------------|
| deployed | 2/11/97 1800 (Z) |
| recovered | 2/20/97 2320 (Z) |
| latitude N | 40 22.599 (deployed) |
| longitude W | 70 40.189 (deployed) |
| water depth | 87.6 meters |

TABLE 36. Shark VLA hydrophone spacing

| Depth (m) | phone number |
|-----------|--------------|
| 35.7 | 0 |
| 37.9 | 1 |
| 41.2 | 2 |
| 44.5 | 3 |
| 47.8 | 4 |
| 51.1 | 5 |
| 54.4 | 6 |
| 57.7 | 7 |
| 61.0 | 8 |
| 64.3 | 9 |
| 67.6 | 10 |
| 70.9 | 11 |
| 74.2 | 12 |
| 77.5 | 13 |
| 80.8 | 14 |
| 84.1 | 15 |

TABLE 37. Shark VLA external navigator

| | |
|--------------------|--------------------|
| navigator | #009 @ 33.5 meters |
| transponder depths | 87.6 meters |

TABLE 38. Shark navigator locations

| Transponder frequency | latitude (surveyed) | longitude (surveyed) |
|-----------------------|---------------------|----------------------|
| 11.0 kHz | 40 22.3496 | 70 39.8827 |
| 11.5 kHz | 40 22.7977 | 70 40.1860 |
| 12.0 kHz | 40 22.3935 | 70 40.4087 |

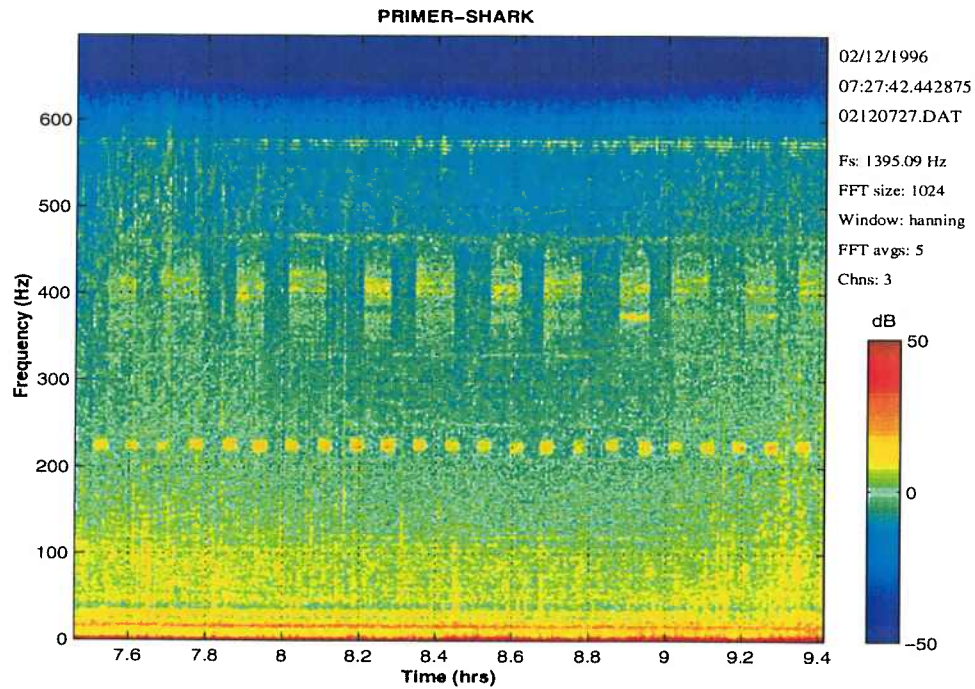


FIGURE 59. Frequency receptions for the Shark just after deployment.

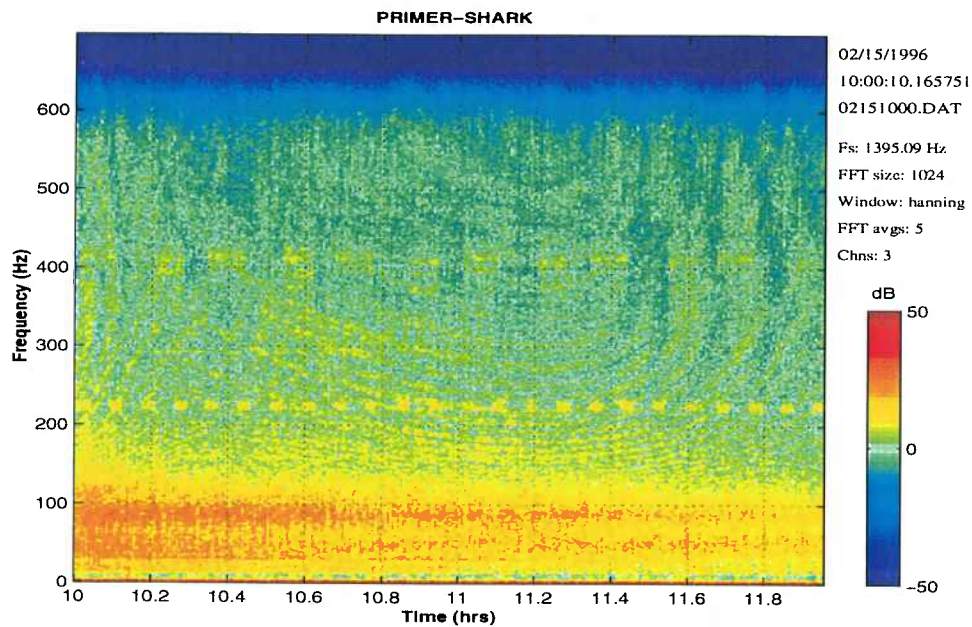


FIGURE 60. Frequency receptions for the Shark just before recovery. The circular patterns are ship noise frequencies.

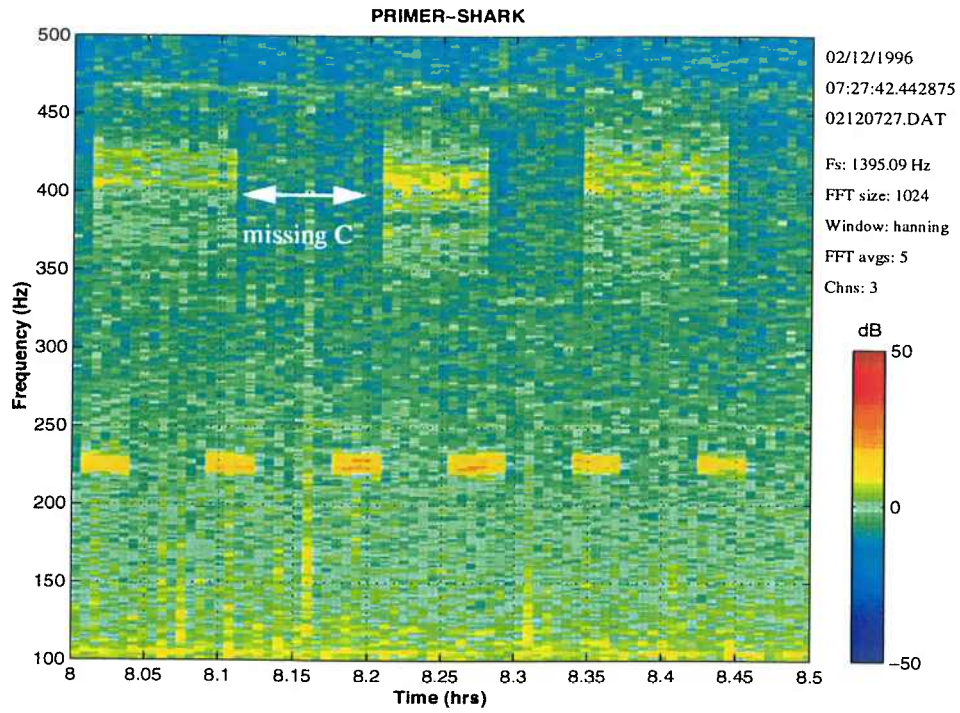


FIGURE 61. Zoomed in portion of Shark receptions just after deployment showing missing mooring C signals.

Primer4 – Shark Voltages – 02151000.dat rec 294

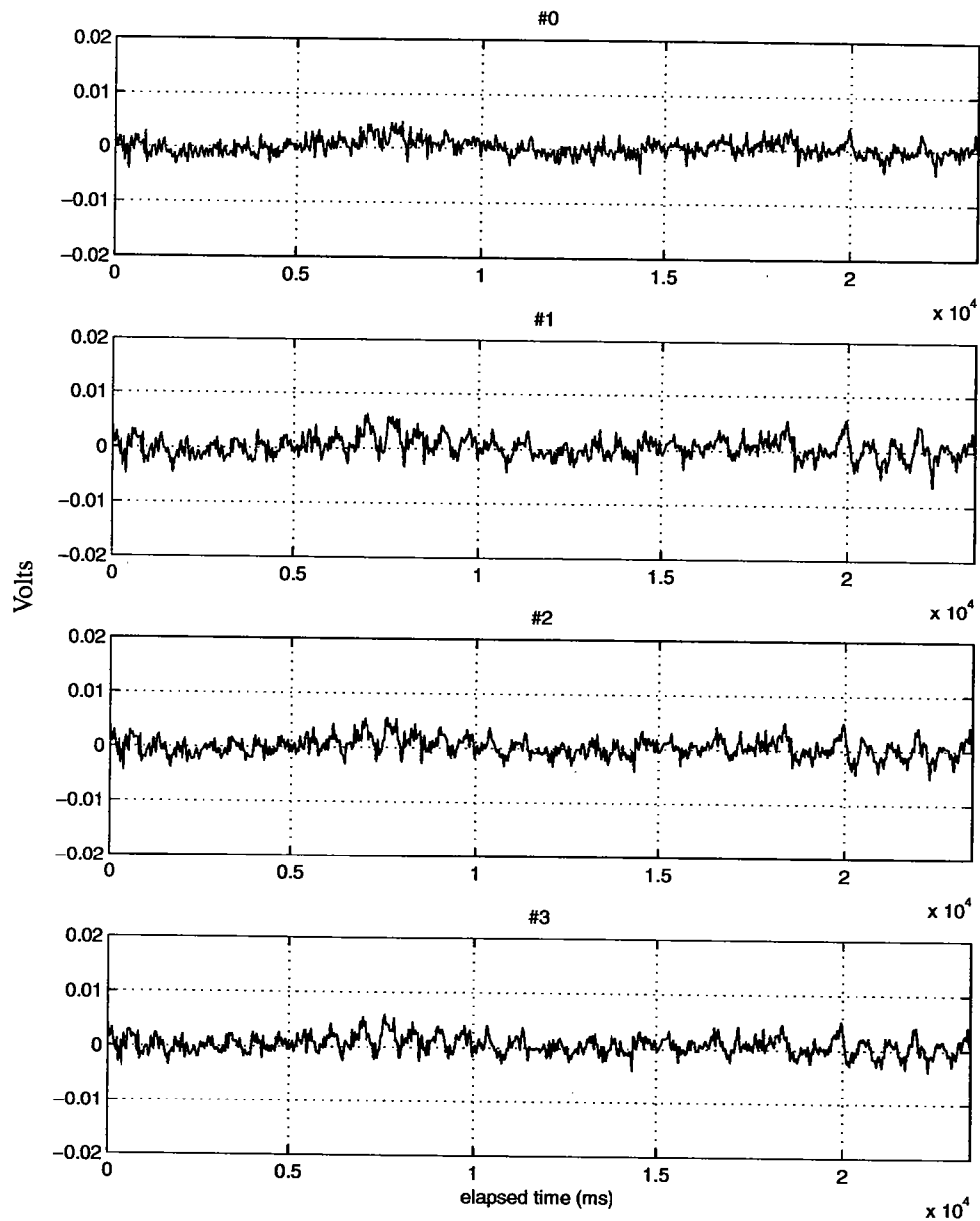


FIGURE 62. Shark individual phones #0-3 at recovery. Elapsed time is in milliseconds $\times 10^4$.

Primer4 - Shark Voltages - 02151000.dat rec 294

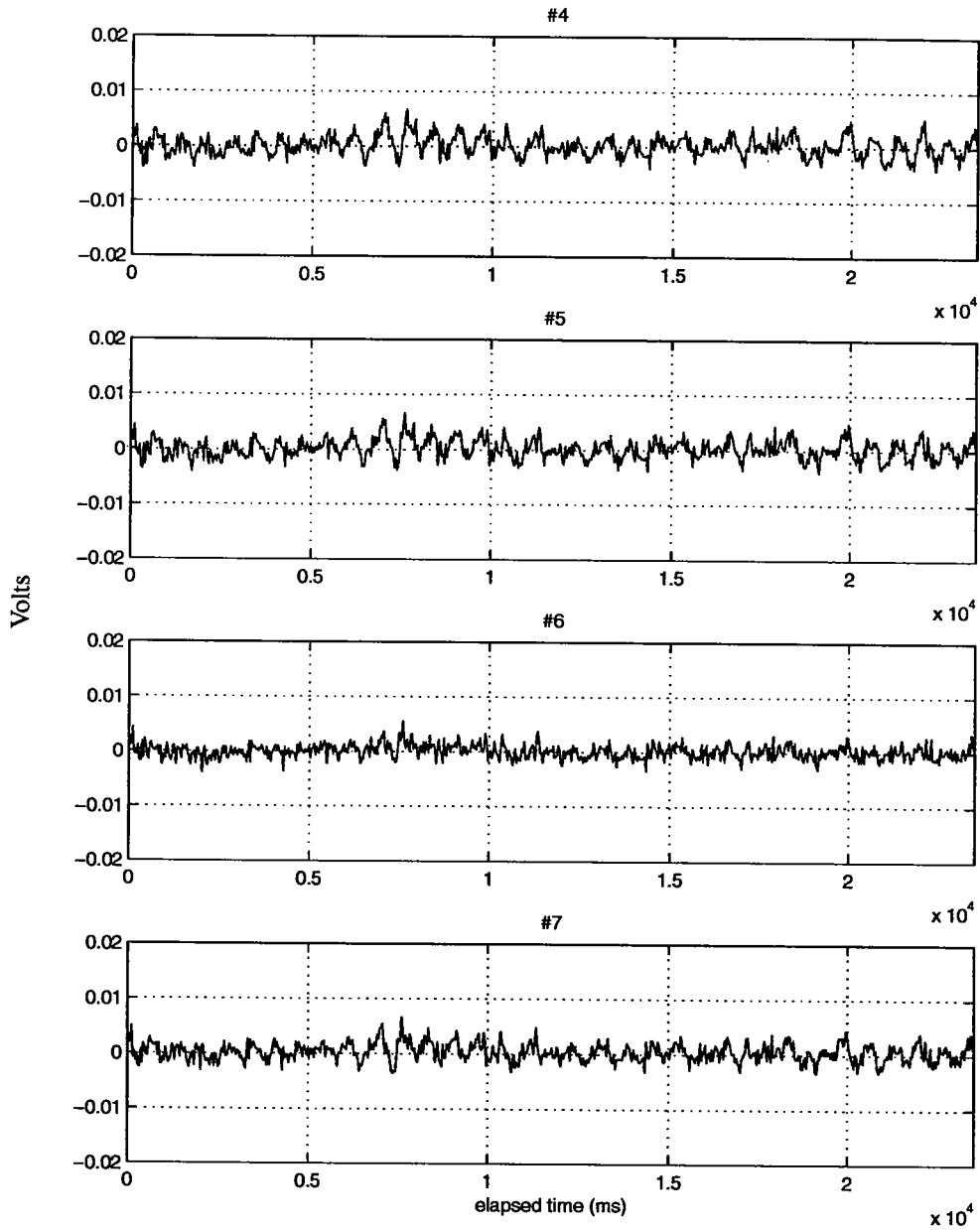


FIGURE 63. Shark voltages for phones #4-7 at recovery. Elapsed time is in milliseconds $\times 10^4$.

Primer4 – Shark Voltages – 02151000.dat rec 294

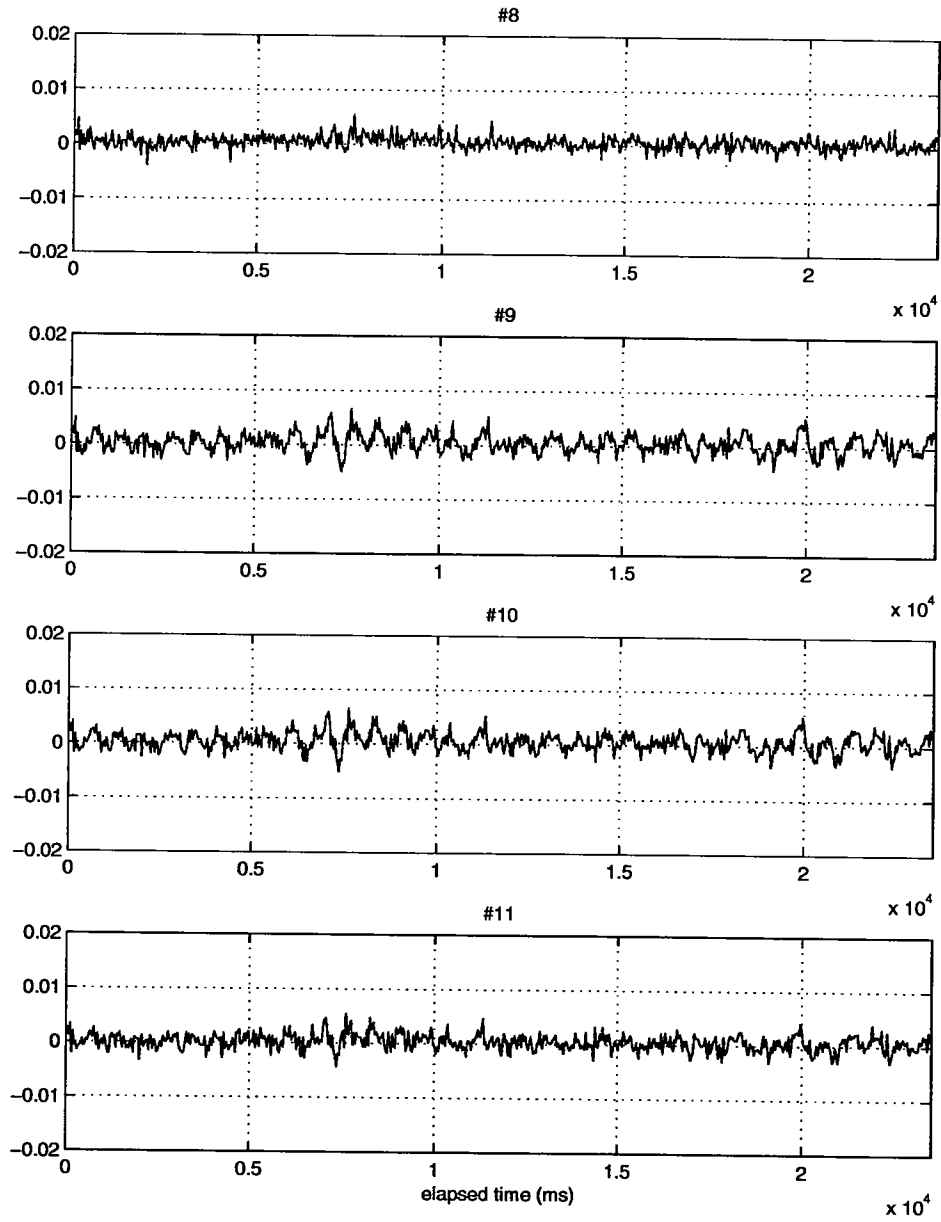


FIGURE 64. Shark voltages for phones #8-11 at recovery. Elapsed time is in milliseconds $\times 10^4$.

Primer4 – Shark Voltages – 02151000.dat rec 294

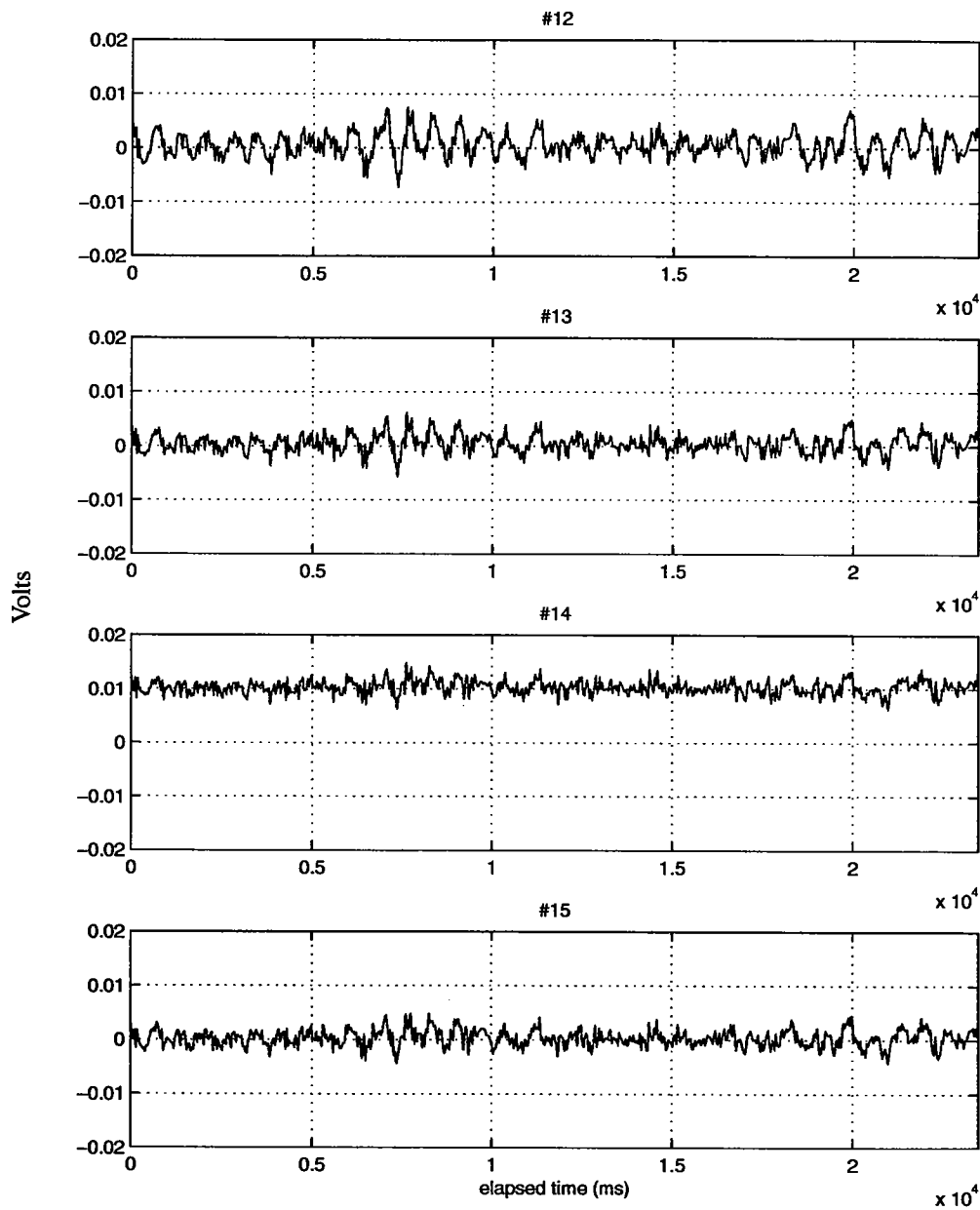


FIGURE 65. Shark individual phones #12-15 at recovery. Elapsed time is in milliseconds $\times 10^4$.

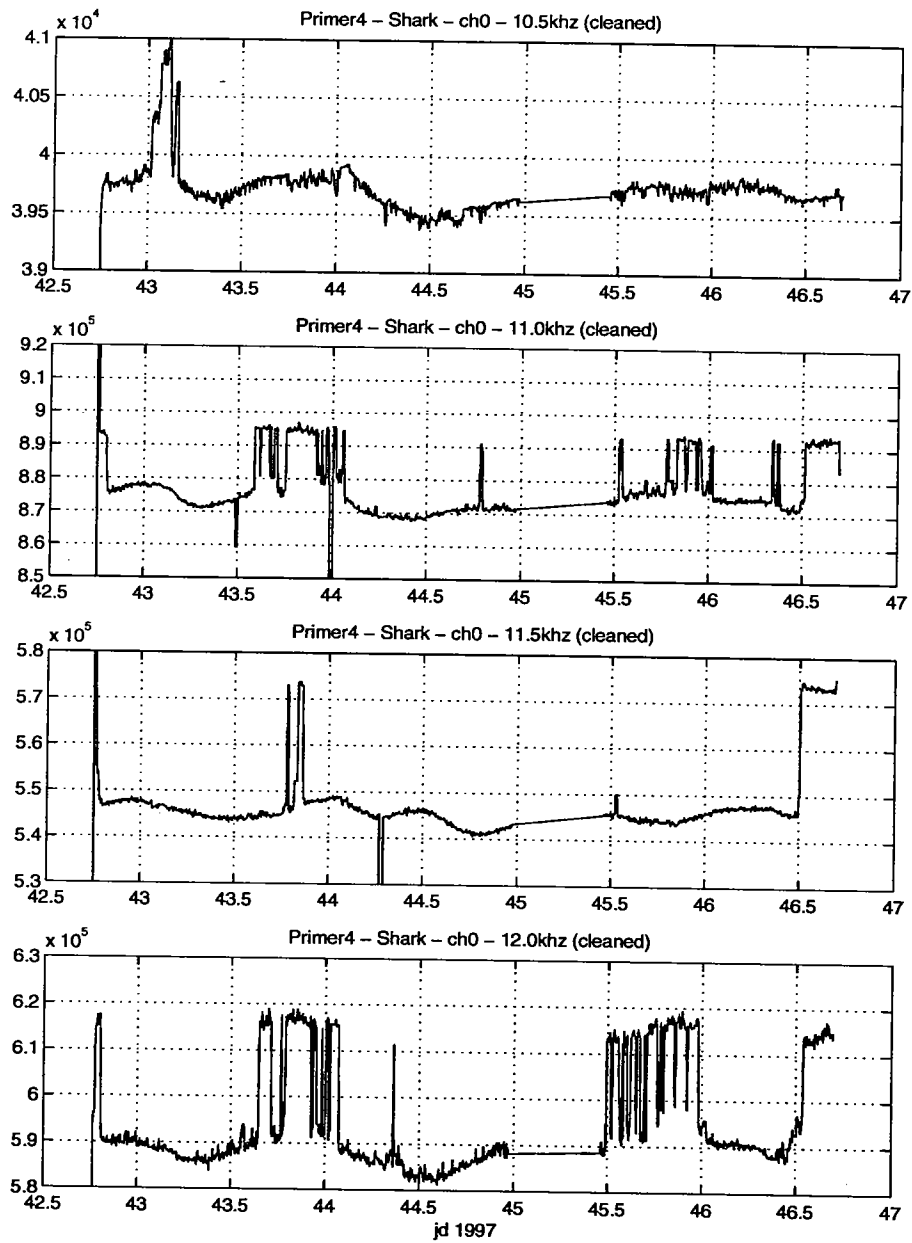


FIGURE 66. Shark internal navigation 2-way travel times in milliseconds for channel #0 Jumps are due to multipath arrivals.

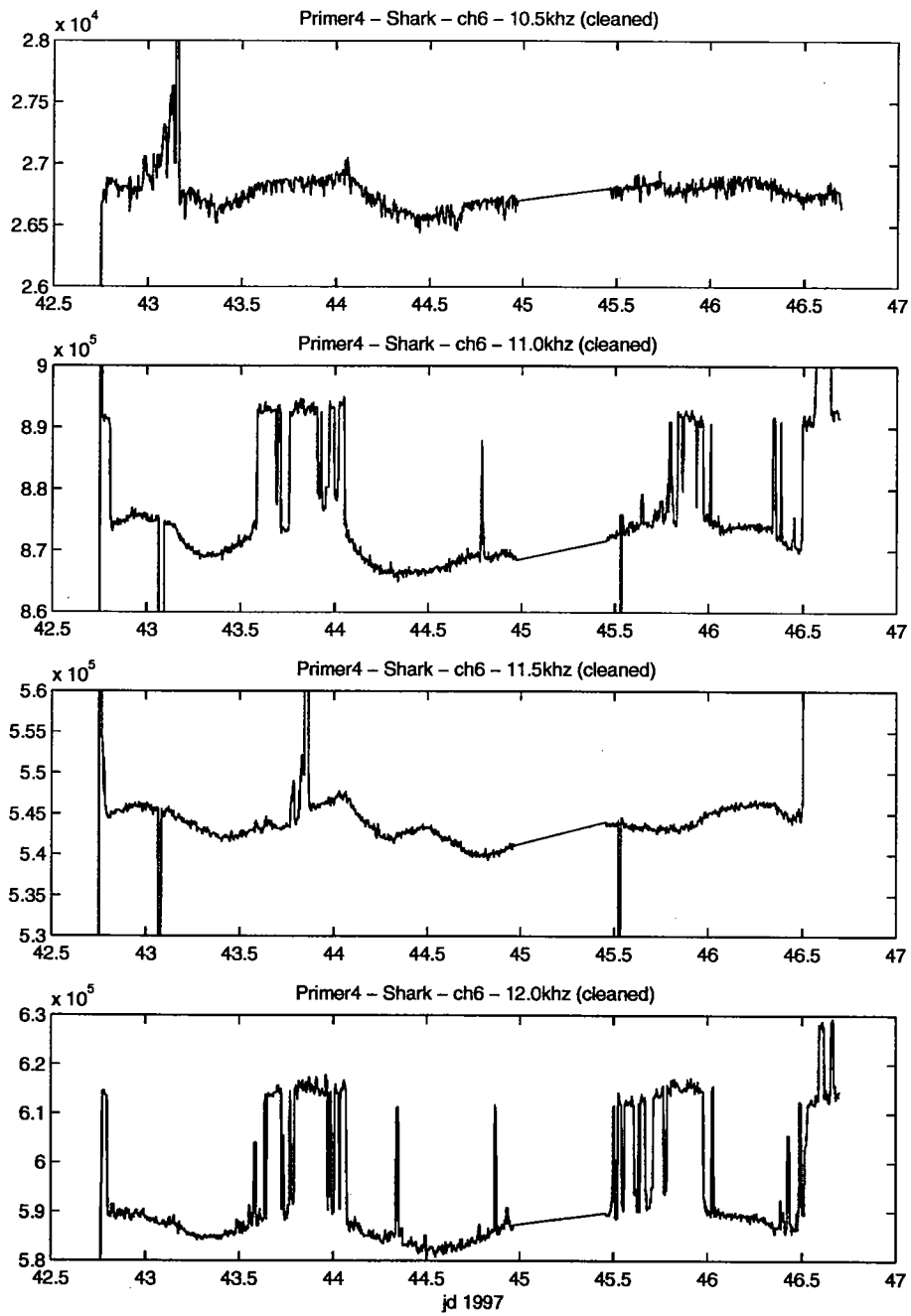


FIGURE 67. Shark internal navigation 2-way travel times in milliseconds for channel #6.

Primer4 – Travel Times for #09 Navigator for Shark

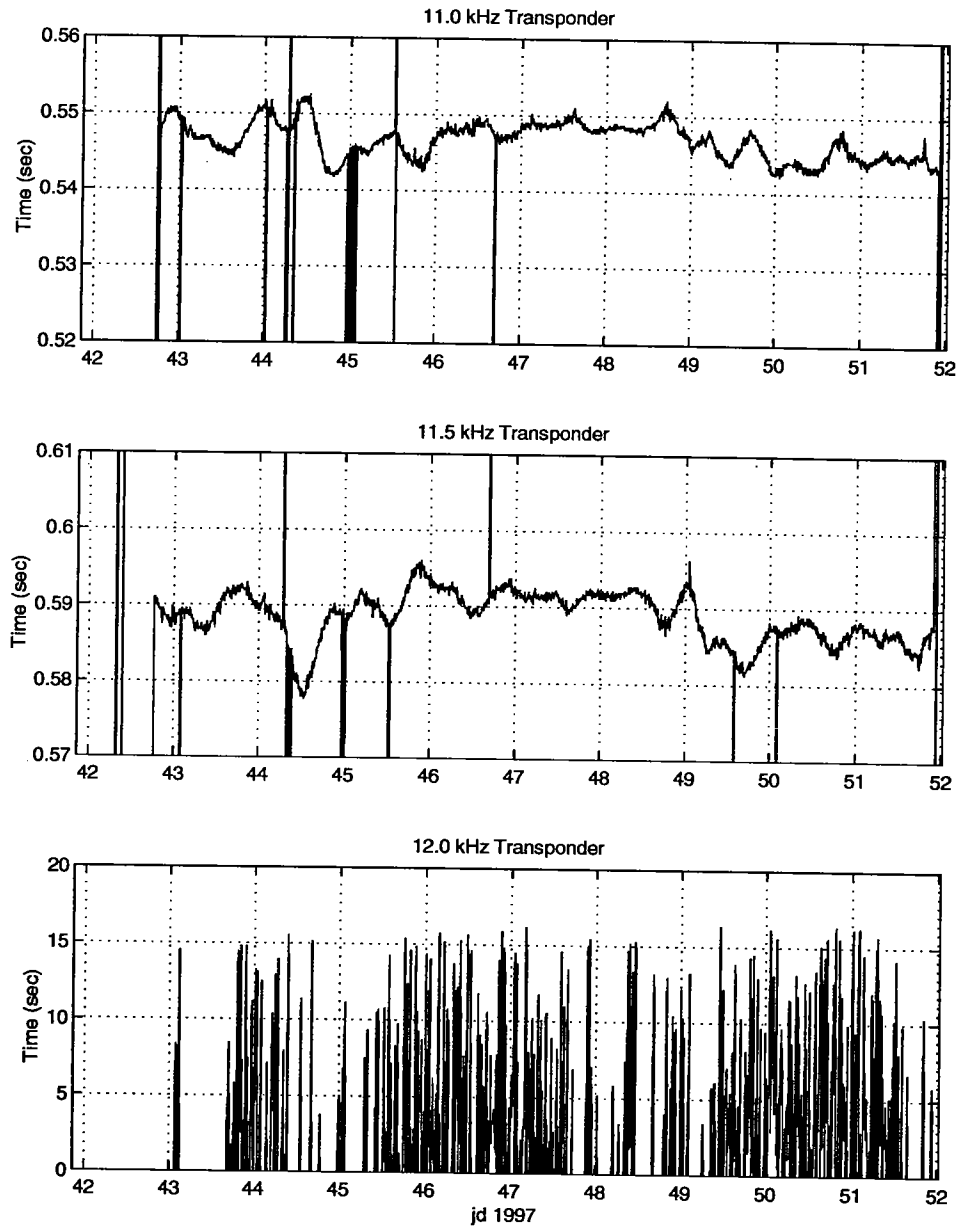


FIGURE 68. Travel times for Shark's external navigator.

2.7.3 “Shark of Science” data tape status

Acoustic data from Feb. 11th to Feb. 15th was saved from the Shark’s internal disk to 8mm Exabyte data tapes. The data tape format is below. Data tape 00 has 18 data files, 4 of which have less than 300 records. All the other datafiles are full with 300 records. Data tape 01 has 17 data files. Three have less than the full 300 records. Data tape 02 has 15 data files. Three have less than the full records. Data tape 03 has 10 full data files and contains the last full record file named 02151529, which ends at 1647 hours.

TABLE 39. File starting times for shark data tape 00

| | | | | |
|----------|----------|----------|----------|----------|
| 02111605 | 02111803 | 02112000 | 02112158 | 02112315 |
| 02120113 | 02120137 | 02120147 | 02120152 | 02120350 |
| 02120416 | 02120530 | 02120727 | 02120925 | 02121122 |
| 02121320 | 02121517 | 02121715 | | |

TABLE 40. File starting times for shark data tape 01

| | | | | |
|----------|----------|----------|----------|----------|
| 02121849 | 02122047 | 02122244 | 02130042 | 02130239 |
| 02130437 | 02130634 | 02130638 | 02130757 | 02130811 |
| 02131009 | 02131206 | 02131403 | 02131601 | 02131616 |
| 02131814 | 02132011 | | | |

TABLE 41. File starting times for shark data tape 02

| | | | | |
|----------|----------|----------|----------|----------|
| 02132132 | 02132329 | 02140127 | 02140324 | 02140522 |
| 02140719 | 02140917 | 02141052 | 02141249 | 02141447 |
| 02141512 | 02141710 | 02141907 | 02142105 | 02142302 |

TABLE 42. File starting times for Shark data tape 03

| | | | | |
|----------|----------|----------|----------|----------|
| 02150012 | 02150210 | 02150408 | 02150605 | 02150802 |
| 02151000 | 02151157 | 02151332 | 02151529 | 02151647 |

2.7.4 Data format for both acoustic arrays

Approximately 30GB of data were stored on disks aboard the WHOI VLA telemetry buoy (WVLA) and the “Shark of Science” (Shark) sled. The Shark data are essentially gap free except for the few seconds between partition swaps on a disk drive and as much as a minute between disk drive changes. In all but these and a very few other “non-problem”

cases involving recording breaks of a minute or so, data on any partition are seamless between files.

Data were subsequently copied while still aboard R/V Endeavor onto 8mm tape using Exabyte model 8505 drives. An additional 3 complete copies have been made, direct from the instruments' disk drives, in the lab at WHOI.

On the tapes the block size is always 1024 bytes and standard filemarks are used. The format of the Primer4 data tapes is nearly identical (the data portion of tapes is identical) to the Primer3. If data other than time/date/rec-length are desired from the Data Record Headers (DRH), review the data record header format shown below. All Primer4 tapes begin with the same 1K byte ``TAPE HEADER" followed by a filemark. The format of this tape header is:

```
struct tape_header      /* 1024 bytes total      */
{
    unsigned char hkey[4]; /* tape header key, "MTHD"      */
    unsigned char sn[16]; /* Tape S/N, 15 chars          */
    /* Tape S/N forms are: 96SHARK_dd_c \& 96BUOY_dd_c, dd=disk#, c=copy# */
    unsigned int  dtime[4]; /* date/time header was written */
    /* year, unsigned int; month/day, 2 packed unsigned chars          */
    /* hour/minute, unsigned int; second/millisecond, unsigned int     */
    unsigned char unused[880]; /* unused bytes                */
    char          ayear[16]; /* year, ascii (1995)          */
    char          amonth[16]; /* month, ascii                */
    char          aday[16]; /* month-day #, ascii          */
    char          ahour[16]; /* hours, ascii                */
    char          aminute[16]; /* minutes, ascii              */
    char          asec[16]; /* seconds, ascii              */
    char          snl[16]; /* tape S/N, 15 chars          */
    unsigned char hkeyl[4]; /* repeat of tape header key ``MTHD" */
};
```

A data file is a contiguous sequence of records, each beginning with a 1 Kbyte data record header (DRH), in which the record size, number of channels, acoustic navigation info, etc. are identified. The files are forced to be a length of about 2 hours in the interest of manageable size. Shark data was always acquired at 1395 Hz and has flat bandwidth of 523 Hz, (-3dB @572 Hz). On both systems, data are simultaneously sampled across all channels by an array of Sigma-Delta converters which apply an FIR filter of constant 28 sample period group delay. The exact sample rate is given by $5,000,000/7/256/2$. Buoy data is at 3906.25 Hz sample rate with a flat bandwidth of 1465 Hz. Most files are 300 records (314880000 Bytes) in length. Data are normally seamless between such files but times should be checked.

Filenames are of the form mmddhhnn.DAT where mm = month, dd = day, hh = hour and nn = minute UTC, so a file's name approximates its start time to the minute.

Data records are always 1025 KBytes in length which includes the 1024 byte DRH. DRH information from both systems includes record number, time to the microsecond and some engineering data some of which is in both binary and ASCII form so it's possible to "figure out" where one is by viewing an ASCII representation of a DRH. Acoustic navigation data were not recorded on the Buoy array because of a yet to be discovered problem, but were recorded by the Shark system. One will note isolated inconsistencies in the Shark nav data because the backup nav interrogator at the top of the array occasionally pinged at the same time as the instrument driven bottom pinger, causing the transponder receptions to be garbled.

Following each DRH are multiplexed data consisting of an integral number of scans of all 16 channels. A data record containing WVLA data will be of the following form.

```
DRH <1024 bytes>,
VLA chan 0 value, chan 1 value, chan 2 value, ... ,VLA chan 15 value,
etc., an integral number of scans as well as 1024 byte blocks
DRH <1024 bytes>,
VLA chan 0 value, chan 1 value, chan 2 value, ... ,VLA chan 15 value,
etc., an integral number of scans as well as 1024 byte blocks
.
.
.
EOF
```

Data are stored as unsigned short (2 bytes), with the lower byte occurring first followed by the upper byte. The bits are high true, i.e an active bit is a "one" or high logic level. The 16 bit sample consists of a 14 bit, 2's complement mantissa (M12 is msb), in the low part of the word with the 2 gain bits in the lower part, (G1 is msb). The sign bit is in the 15th bit position, (0 is positive). Bits 0 through 7 are the low byte and bits 8 through 15 are the high byte of the stored sample. The exponent represents effective gains of 1, 8, 64 and 512 with 00, 01, 10, and 11 respectively. These correspond to left shifts of 0, 3, 6 and 9 bits in the raw 23 bit magnitude.

```
Bit 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01 00
      SN M12 M11 M10 M09 M08 M07 M06 M05 M04 M03 M02 M01 M00 G1 GO
      {+/-}{      13 BIT MANTISSA      } {'GAIN'}
```

There are always 32768 16 channel scans in a record. Following the last block of a record, will be the next DRH, followed by more data. Time to the microsecond of the first sample in any record and the record number are recorded in the record header as shown in the "C structure" used to define the 1024 byte Data Record Header (DRH). The start time value wobbles about some (usually only a few milliseconds), due to the interrupt response time of the acquisition system. Note that number types are from the PC world where "ints" are shorts, 2 bytes, and "longs" are 4 bytes.

```
struct data_rec_hdr          /* 1024 bytes total          */
{
```

```

unsigned char rhkey[4]; /* header key, "DATA" */
unsigned int date[2]; /* date[0]=year, date[1]=Year-day# */
unsigned int time[2]; /* time[0] = (hours*60 + minutes) */
/* time[1] = (seconds*1000 + milliseconds) */
unsigned int microsec; /* microseconds */
unsigned int rec; /* number of record that follows */

unsigned int ch; /* # channels <16> */
long npts; /* # sample periods per record <32768> */
float rhfs; /* sample rate in Hz <1395.089286> */
unsigned int rlen; /* rec length in blocks, includes DRH <1025>*/
long rectime; /* record time in microsec <??> */

char rhlat[16]; /* lat, ascii DDD MM SS.T N or E <approx> */
char rhlng[16]; /* long, ascii DDD MM SS.T E or W <approx> */

long nav_data[16]; /* PRIMER-96 VLA acoustic nav data */
/* The format is 4 groups of 4 long tt's */
/* where the sequence in each group is */
/* 10.5, 11.0, 11.5, 12.0 KHz TT's */

long nav_windows[4]; /* measured window times in microsecs */
/* ch 0 (top), ch 6, ch 11, ch 15 */
unsigned char unused1[612]; /* not used for PRIMER-96 */

int vit_flag; /* no-zero indicates vit this record */
unsigned int vit_mh;
unsigned int vit_ms;
int nav_flag; /* non-zero indicates nav this rec */
unsigned int nav_mh; /* the time of the nav suite, mh */
unsigned int nav_ms; /* the ms part of the time */

long bw; /* LAN link BW in bytes/s for previous rec */
float fit; /* float version of internal temp */
float fbv; /* float version of bat voltage */
float fbc; /* float version of bat current */

char internal_temp[16]; /* internal instrument temp, ascii */
char bat_voltage[16]; /* main battery voltage, ascii */
char bat_current[16]; /* main battery current, ascii */
unsigned char status[16]; /* for AD24 status bytes if marker bit err */

char proj[16]; /* project name, ascii <PRIMER> */
char exp[16]; /* ascii representation of Exp # */
char vla[16]; /* VLA sensitivity <-170 db> */
char hla[16]; /* HLA sensitivity <-170 or 0 if not used> */
char fname[16]; /* ascii file name <mmddhhnn.dat> */

```



```

char    record[16];    /* ascii representation of rec #, REC ##### */
char    adate[16];    /* ascii representation of date, mo/da/yr */
char    atime[16];    /* ascii rep of rec time, hr:mn:ss.mmmmmm */

char    unused2[4];
int     vit_period;    /* period in minutes of VIT update */
int     nav_period;    /* acoustic nav period, min for PRIMER-96 */
int     adc_rate_code; /* AD24 rate code, {6,5,4,3,2,1,0} <5> */
int     adc_mode;     /* 0 =fixed point, 1 = 24 bit, 2 = pfp */
int     adc_clk_code; /* timebase divider to get AD24 clock */
unsigned int scan_blocks; /* # 512 pt scans per AD24 */

long    timebase;     /* 5000000 Hz */
long    xbuf_size;    /* xm space in use */
long    wr_xbuf;     /* ptr to first xm buffer, this record */
long    rd_xbuf;     /* linear address of data buffer, this rec */

unsigned int xm_block_size; /* size of block transfers to xm space/intr */
unsigned int xmbufs;     /* # xmSPACE buffers */
unsigned int xbufs_per_rec; /* # xm_block_size chunks per record */
char    data_error1;    /* tba */
char    data_error2;    /* tba */
char    ovf;           /* data buffer overflow count */
char    tbufs;         /* # rec/time buffers (max ip_flag, op_flag */
char    ip_flag;       /* input buffer # */
char    op_flag;       /* output buffer # */
char    rhkeyl[4];     /* end of rec header key "DATA" */
};

```

Sample rate is a function of the Delta-Sigma ADC architecture and the ADC clock. The Buoy has some flexibility to change divider ratios to change the rate; however all data were at the 1395 kHz rate.

For each data file, there exists an ASCII log file which contains the status information available at the time each record is stored. Among the information logged in this file is the acoustic NAV data. A copy of these log files for both the Buoy and the Shark are on a tape as part of each data copy. It is much easier to extract the NAV data from these files rather than the data tapes. Logfile excerpts from both Shark and Buoy are shown. Note the large MAX/MIN values from CH 15, at the bottom of the VLA. The NAV pinger output is responsible for the higher than normal levels which are given in volts output from the sensor. The same symptom is evident on CH 0 on both arrays when the interrogator just beneath the subsurface float fires. The sensor sensitivity is -170 dBV re 1V/ μ Pa and is capable of a maximum linear output of 1Vpp, corresponding to a pressure peak of 160dB re 1 μ Pa. A NAV suite occurred every 4 minutes starting at 2 minutes after the hour. The interrogator at the VLA top initiated a cycle every 5 min on the hour. The NAV data are shown in microseconds as a measurement of the roundtrip traveltime from the pinger at the base of the VLA to the transponder and back to the selected VLA channel. The times

measured include the "turn-around time" for the Benthos transponder and the recognition-time for the Sonatech detectors used at the Shark. The Sonatech recognition time has been shown to be about 4 ms with a jitter of less than .2 ms.

At the 4 minute interval, the time is reported in the logfile after "NAV INTR @....", the 10.5 KHz pinger (in the SHARK sled it was about .5m above the bottom) was triggered to emit a sequence of 4 - 10ms tone bursts with an SPL of about 185 dB, each separated by 5.00 seconds. At each occurrence of the trigger, a timer with microsecond resolution and at least 10 microseconds accuracy was started for all 4 detectors.

All 3 transponders respond as they hear the 10.5 KHz ping.

Ch 0 (TOP), 6, 11, and 15 are sequentially connected to the 4 ch detector with the time of the first detection for each of the 4 frequencies logged during each of 4 - 5 second detect windows. Therefore, it takes 20 seconds to complete a NAV interrogation suite. The low frequency data acquisition was uninterrupted.

After the completion of a NAV sequence, the NAV system was dormant until the next 4 min interval had elapsed. Nominally, NAV times should have been @ 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, and 54 min after the hour.

Sample Shark logfile from Primer3 at the beginning of a file:

```
NEW FILE C:07240344.dat @rec 1200, disk space = 32866304
R 1200 ov00 op00 ip01 TIME 03:44:28.697 23488103 -0037953 02097152 02564096
Unit 00 disk C: space = 32866304, Status: 00 00 00 00
MAX @ ch 12 0.003212 MIN @ ch 4 -0.002159

R 1201 ov00 op01 ip02 TIME 03:44:52.185 23488103 -0037953 03145728 03612672
Unit 00 disk C: space = 31784960, Status: 00 00 00 00
MAX @ ch 0 0.015106 MIN @ ch 0 -0.029960

R 1202 ov00 op02 ip03 TIME 03:45:15.673 23488103 -0037952 04194304 04661248
Unit 00 disk C: space = 30703616, Status: 00 00 00 00
MAX @ ch 9 0.003238 MIN @ ch 4 -0.002620

R 1203 ov00 op03 ip04 TIME 03:45:39.162 23488101 -0037954 05242880 05709824
Unit 00 disk C: space = 29655040, Status: 00 00 00 00
MAX @ ch 15 0.119268 MIN @ ch 15 -0.114873

NAV INTR @ 03:46:00.000524.....(ch 0 is top)
ch 00 0039624 0961414 0406879 0719174
ch 06 0026859 0960820 0405201 0718366
ch 11 0013452 0959555 0404446 0716962
ch 15 0007692 0958858 0403760 0717206
10.5 win=5032460 11.0 win=5035894 11.5 win=5000338 12.0 win=5000412
```

R 1204 ov00 op04 ip05 TIME 03:46:02.650 23488104 -0037952 06291456 06758400
Unit 00 disk C: space = 28606464, Status: 00 00 00 00
MAX @ ch 15 0.116455 MIN @ ch 15 -0.113994

An excerpt from a Buoy data file from Primer3 is shown. The "VIT" line shows the time of a measurement of battery voltage, battery current in amps, and the internal temperature of the BUOY taken at a point next to the DX40 CPU, degrees C. Again the high level at the bottom sensor is evident when the NAV pinger fires. The lack of NAV data is evident as well.

R 1808 ov00 op08 ip09 TIME 17:33:27.501 23488102 -0000679 10485760 10752000
Unit 00 disk C: space = 245825536, Status: 00 00 00 00
MAX @ ch 1 0.009503 MIN @ ch 12 -0.008616

VIT: 17:34:00.000: Voltage=32.2 Current=1.503 Temp=31.9

NAV INTR @ 17:34:00.000536....

ch 0 0000000 0000000 0000000 0000000
ch 1 0000000 0000000 0000000 0000000
ch 2 0000000 0000000 0000000 0000000
ch 3 0000000 0000000 0000000 0000000

10.5 win=5000405 11.0 win=5000286 11.5 win=5004038 12.0 win=5020464

R 1809 ov00 op09 ip10 TIME 17:33:50.989 23488104 -0000677 11534336 11804672
Unit 00 disk C: space = 244776960, Status: 00 00 00 00
MAX @ ch 15 0.080629 MIN @ ch 15 -0.084990

R 1810 ov00 op10 ip11 TIME 17:34:14.477 23488101 -0000678 12582912 12849152
Unit 00 disk C: space = 243728384, Status: 00 00 00 00
MAX @ ch 15 0.076827 MIN @ ch 15 -0.084133

VIT: 17:35:00.000: Voltage=32.2 Current=1.298 Temp=31.9

R 1811 ov00 op11 ip12 TIME 17:34:37.965 23488102 -0000679 13631488 13897728
Unit 00 disk C: space = 242679808, Status: 00 00 00 00
MAX @ ch 8 0.007560 MIN @ ch 2 -0.008065

The realtime clock in both systems were synchronized to UTC provided by the shipboard GPS clock. Prior to deployment a time offset was recorded. Subsequent to recovery, the time offset was again measured so that an average clock drift rate can be estimated.

These data are:

Shark

Rel UTC before deployment: @ 7/23, day 205 1430Z....SHARK lags UTC by 0.76 ms
after recovery: @ 8/04, day 217 1237Z....SHARK lags UTC by 5.20 ms
corresponding to about 4.3 parts in 10e9 or about 370 microseconds/day, average.

WVLA

Rel UTC before deployment: @ 7/23, day 205 1430Z....BUOY lags UTC by 0.44 ms
after recovery: @ 8/05, day 218 1435Z....BUOY lags UTC by 4.65 ms
corresponds to about 3.75 parts in 10e9 or about 325 microseconds/day, average

The relationship between Sample_O/P_Rate and BW is:

$$\text{Sample_O/P Rate} = (\text{CLOCK} / 256) / (2^{(6-\text{ADC_Rate_Code})})$$

The relationship for flat DATA BW (Hz) and Sample_O/P_Rate is:

$$\text{BW} = .375 * \text{Sample_O/P_Rate}$$

The relationship between Flat BW and storage/telemetry rate is:

$$\text{Telemetry_Rate} = (\text{BW} / .375) * \text{CHANNELS} * 2$$

The CLK frequency is the Austron 5 MHz output divided by "n".

Data can be normalized to volts at the output of the sensor as follows:

The 2 bit gain code represents up to 3 - 3-bit left shifts of the original 24 bit ADC word.
This can be treated as $\text{exponent} = 1 \ll ((\text{stored value} \& 0x03) * 3)$.

$\text{mantissa} = (\text{value} \gg 2)$ (13 bits and sign bit)

Differential amp fixed gain = 10

Full scale digital value of ADC is 5242880. Hence, the factor .625 results from
 $5242880 / (2^{23})$

Full scale ADC input voltage is $\{\text{em} \pm 4.5\}$

Hence: $\text{normalized value} = (4.5 * \text{mantissa}) / (2^{13}) / .625 / \text{exponent} / 10$

"C" code that to do this is:

```
exp = 1 << ((p[i]&0x03)*3); /* where p[i] is a raw data value */  
fprintf(outfile, "%08f\n", (double)(p[i]>>2)*4.5/8192/exp/.625/gain);
```

2.8 SUS charges

To provide broadband acoustic transmissions that can be inverted for both water column and ocean bottom soundspeed profiles, Mark 61 1.8 lb explosive charges were dropped from a NAWC P-3 aircraft. The charges were set to detonate at 18 meters depth and were dropped along lines both inside and outside the tomography area. Conventional tomography provides a longer time series over a smaller area while the SUS drop provides a temporal "snapshot" over a larger spatial area and over a larger acoustic bandwidth. These

positions were taken directly from the NAWC Air Ops log book. The longitude position may not be accurate enough for our analysis since they are all the same. Some SUS runs were performed west to east at a single latitude. The longitude positions should have changed.

TABLE 43. Feb 19, 1997 SUS drop times and locations from NAWC Air Ops.

| time hhmmss | Latitude degrees N | Longitude degrees W | Remarks |
|----------------|-----------------------|------------------------|-------------|
| 175040 | 71.13 | 40.37 | rev1 - good |
| 175827 | 71.14 | 40.37 | rev1 - good |
| 180325 | 71.13 | 40.37 | rev2 - good |
| 181029 | 71.13 | 40.37 | rev2 - good |
| 181525 | 71.13 | 40.37 | rev3 - good |
| 182252 | 71.14 | 40.37 | rev3 - good |
| 182833 | 71.12 | 40.37 | rev4 - good |
| 183558 | 71.12 | 40.37 | rev4 - good |
| 185542 | 71.14 | 40.37 | run1 - good |
| 185607 | 71.14 | 40.37 | run1 - good |
| 185623 | 71.14 | 40.37 | run1 - good |
| 185642 | 71.13 | 40.37 | run1 - good |
| 185702 | 71.13 | 40.37 | run1 - good |
| 185721 | 71.13 | 40.37 | run1 - good |
| 185742 | 71.13 | 40.37 | run1 - good |
| 185803 | 71.14 | 40.37 | run1 - good |
| 18582 | 71.14 | 40.37 | run1 - good |
| 185842 | 71.15 | 40.37 | run1 - good |
| 185902 | 71.15 | 40.37 | run1 - good |
| 185923 | 71.15 | 40.37 | run1 - good |
| 185944 | 71.15 | 40.37 | run1 - good |
| 190002 | 71.15 | 40.37 | run1 - good |
| 190023 | 71.16 | 40.37 | run1 - bad |
| 190042 | 71.16 | 40.37 | run1 - good |
| 190103 | 71.16 | 40.37 | run1 - good |
| 190123 | 71.16 | 40.37 | run1 - good |
| 190143 | 71.16 | 40.37 | run1 - bad |
| 190201 | 71.16 | 40.37 | run1 - good |
| 190223 | 71.15 | 40.37 | run1 - good |
| 190243 | 71.15 | 40.37 | run1 - good |
| 190302 | 71.15 | 40.37 | run1 - good |
| 190321 | 71.15 | 40.37 | run1 - good |

TABLE 43. Feb 19, 1997 SUS drop times and locations from NAWC Air Ops.

| time hhmmss | Latitude degrees N | Longitude degrees W | Remarks |
|----------------|-----------------------|------------------------|-------------|
| 190342 | 71.15 | 40.37 | run1 - good |
| 191122 | 71.15 | 40.37 | run2 - good |
| 191145 | 71.12 | 40.37 | run2 - good |
| 19120 | 71.10 | 40.37 | run2 - good |
| 191223 | 71.08 | 40.37 | run2 - good |
| 191244 | 71.05 | 40.37 | run2 - good |
| 191304 | 71.03 | 40.37 | run2 - good |
| 191323 | 71.01 | 40.37 | run2 - good |
| 191344 | 70.99 | 40.37 | run2 - good |
| 191404 | 70.97 | 40.37 | run2 - good |
| 191423 | 70.94 | 40.37 | run2 - good |
| 191443 | 70.92 | 40.37 | run2 - good |
| 191506 | 70.90 | 40.37 | run2 - good |
| 192757 | 71.15 | 40.37 | run3 - bad |
| 192819 | 71.12 | 40.37 | run3 - good |
| 192838 | 71.10 | 40.37 | run3 - good |
| 192858 | 71.08 | 40.37 | run3 - good |
| 192917 | 71.06 | 40.37 | run3 - good |
| 192937 | 71.04 | 40.37 | run3 - good |
| 192958 | 71.01 | 40.37 | run3 - good |
| 193019 | 70.99 | 40.37 | run3 - good |
| 193037 | 70.97 | 40.37 | run3 - good |
| 193058 | 70.95 | 40.37 | run3 - good |
| 193117 | 70.92 | 40.37 | run3 - good |
| 193140 | 70.90 | 40.37 | run3 - good |
| 194204 | 71.14 | 40.37 | add1 - good |
| 194343 | 71.13 | 40.37 | add1 - good |
| 194525 | 71.13 | 40.37 | add1 - good |
| 194704 | 71.13 | 40.37 | add1 - good |
| 194846 | 71.13 | 40.37 | add1 - good |

2.9 Vertical CTD casts

Twenty one stationary, vertical CTD casts (figs 69-74) were performed during legs 1 and 2 of Primer4. These were generally done while poor weather conditions prohibited mooring deployment or recovery. An additional section was performed during the July 1997 source pickup cruise (figs 75-77)

TABLE 44. Vertical CTD casts

| cast | date | latitude (N) | longitude (W) | depth (m) | section |
|------|---------|--------------|---------------|-----------|---------|
| 1 | 2/10/97 | 39 59.8833 | 71 11.2333 | 285 | 1 |
| 2 | 2/10/97 | 39 59.8833 | 71 11.2333 | 520 | 1 |
| 3 | 2/10/97 | 39 57.3000 | 71 10.0667 | 384 | 1 |
| 4 | 2/10/97 | 40 02.3167 | 71 10.1333 | 225 | 1 |
| 5 | 2/10/97 | 39 59.550 | 70 44.9300 | 296 | 2 |
| 6 | 2/10/97 | 40 05.600 | 70 45.6000 | 135 | 2 |
| 7 | 2/10/97 | 40 09.8600 | 70 45.0000 | 126 | 2 |
| 8 | 2/10/97 | 40 14.79 | 70 45.00 | 118 | 2 |
| 9 | 2/10/97 | 40 20.05 | 70 45.03 | 97 | 2 |
| 10 | 2/10/97 | 40 22.033 | 70 45.05 | 90 | 2 |
| 11 | 2/10/97 | 40 27.05 | 70 45.03 | 78 | 2 |
| 12 | 2/11/97 | 40 22.0733 | 70 40.0867 | n/a | |
| 13 | 2/15/97 | 40 21.9667 | 71 12.9167 | n/a | 3 |
| 14 | 2/15/97 | 40 19.900 | 71 10.050 | n/a | 3 |
| 15 | 2/15/97 | 40 16.0333 | 71 10.050 | n/a | 3 |
| 16 | 2/15/97 | 40 11.980 | 71 10.050 | n/a | 3 |
| 17 | 2/15/97 | 40 08.000 | 71 10.050 | n/a | 3 |
| 18 | 2/15/97 | 40 04.000 | 71 10.0333 | n/a | 3 |
| 19 | 2/16/97 | 40 22.0733 | 70 40.0867 | n/a | |
| 20 | 2/16/97 | 39 54.2700 | 71 11.4400 | n/a | |
| 21 | 2/16/97 | 39 53.0200 | 71 10.3867 | n/a | |

TABLE 45. Vertical CTD casts from July 1997 source pickup.

| file # | date | time (Z) | latitude (N) | longitude (W) | depth |
|--------|---------|----------|--------------|---------------|--------|
| 1 | 7/19/97 | 20:55:14 | 39 57.06 | 071 09.81 | 500 |
| 2 | 7/19/97 | 22:06:55 | 39 59.15 | 71 9.11 | 317.5 |
| 3 | 7/19/97 | n/a | 39 59.15 | 71 9.11 | 317.5 |
| 4 | 7/19/97 | 23:54:54 | 40 3.06 | 71 8.69 | 210.7 |
| 5 | 7/20/97 | 00:33:39 | 40 4.83 | 71 8.54 | 179.9 |
| 6 | 7/20/97 | 01:09:37 | 40 6.80 | 71 8.09 | 153.5 |
| 7 | 7/20/97 | 01:46:02 | 40 8.82 | 71 7.68 | 136.5 |
| 8 | 7/20/97 | 02:19:56 | 40 10.82 | 71 7.40 | 124.75 |
| 9 | 7/20/97 | 02:54:31 | 40 12.75 | 71 7.09 | 115.8 |
| 10 | 7/20/97 | 03:26:42 | 40 14.76 | 71 6.72 | 105.1 |
| 11 | 7/20/97 | 03:53:34 | 40 16.76 | 71 6.30 | 95.0 |
| 12 | 7/20/97 | 04:20:39 | 40 18.71 | 71 5.89 | 90.5 |

TABLE 45. Vertical CTD casts from July 1997 source pickup.

| file # | date | time (Z) | latitude (N) | longitude (W) | depth |
|--------|---------|----------|--------------|---------------|-------|
| 13 | 7/20/97 | 04:47:05 | 40 20.75 | 71 5.51 | 87.1 |
| 14 | 7/20/97 | 05:11:16 | 40 22.72 | 71 5.08 | 83.4 |

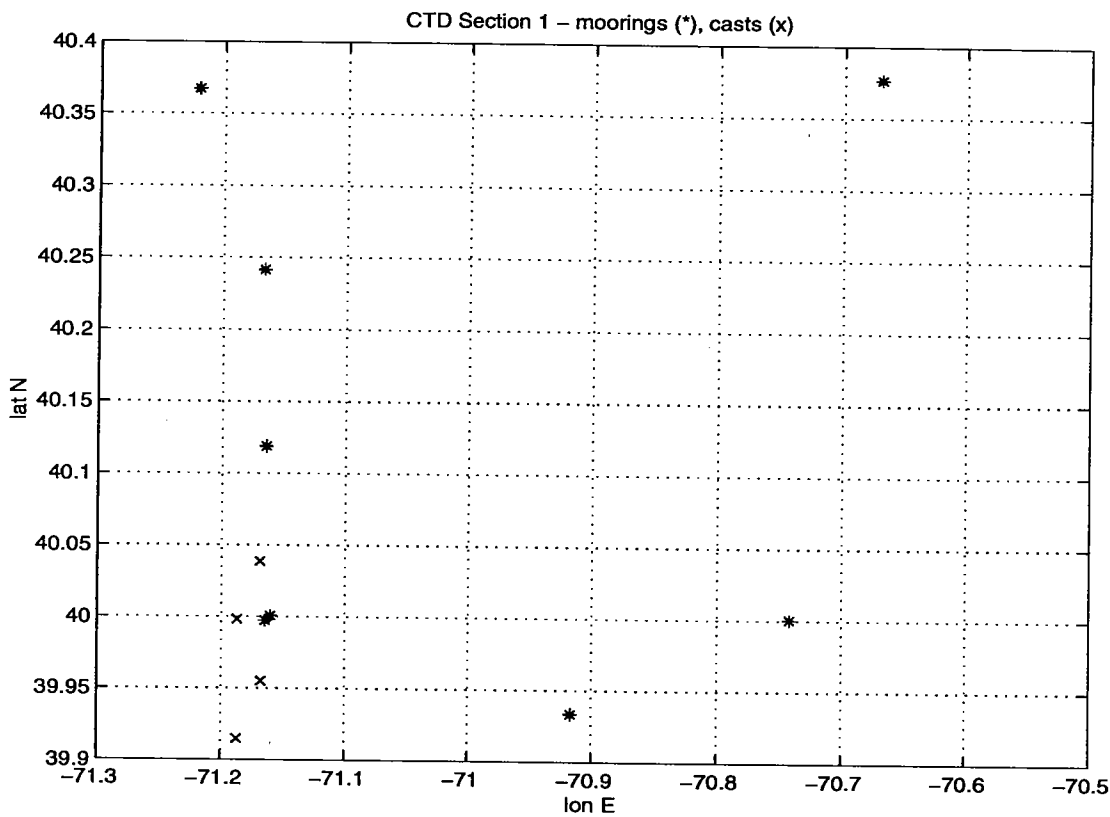


FIGURE 69. CTD section 1 locations - Western leg on Feb 10

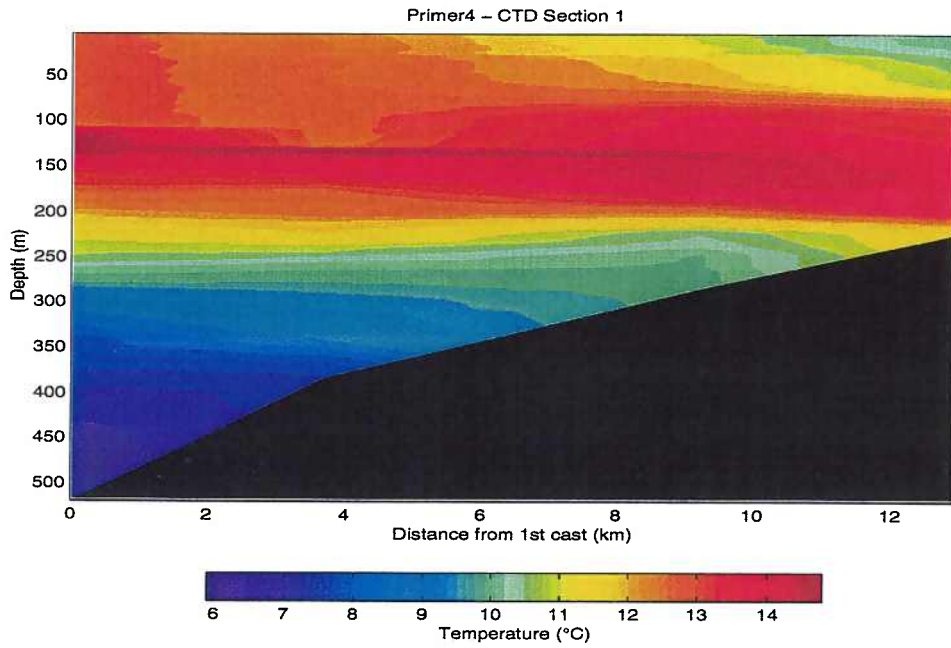


FIGURE 70. CTD temperatures for section 1 on Feb 10 at 1100 hrs (Z).

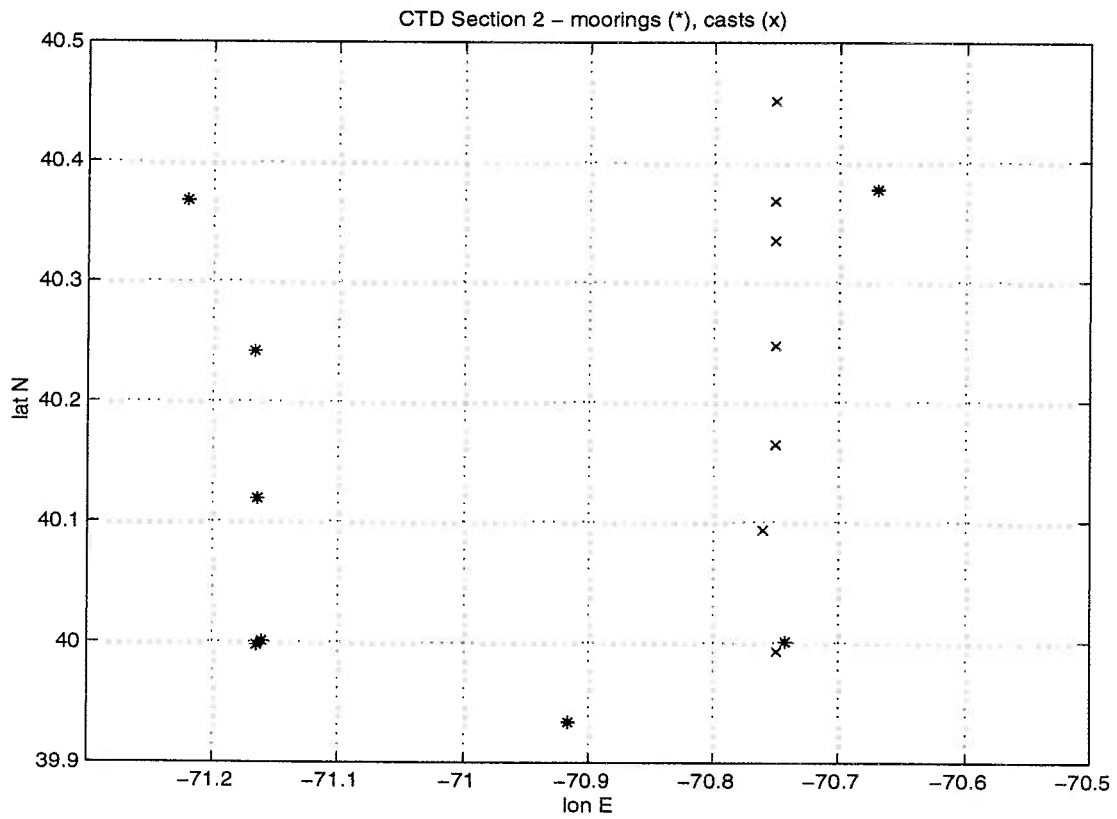


FIGURE 71. CTD section 2 locations - Eastern leg

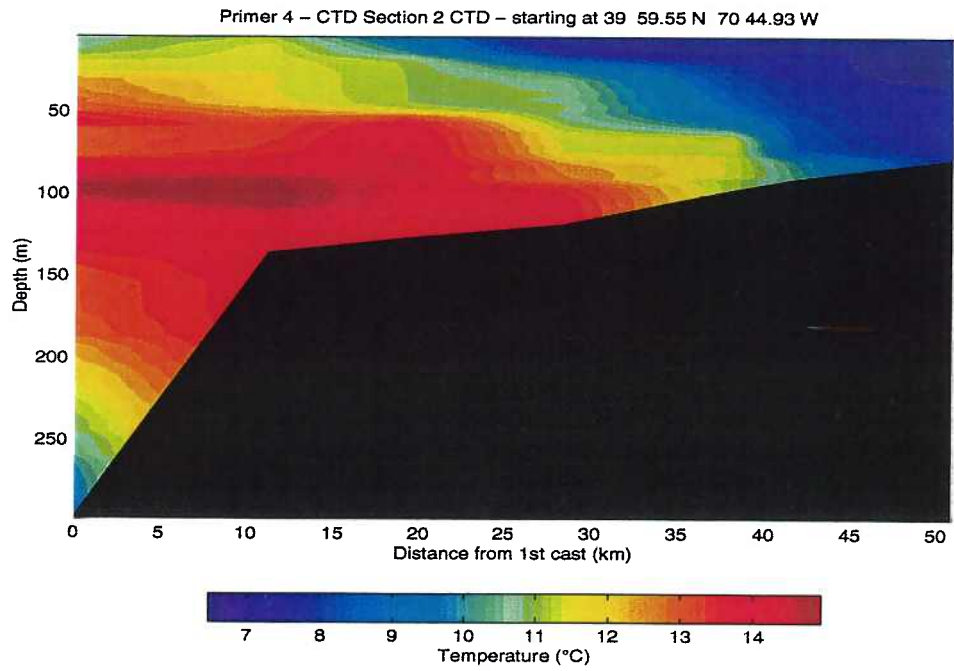


FIGURE 72. CTD temperatures for section 2 on Feb 11 at 0700 (Z)

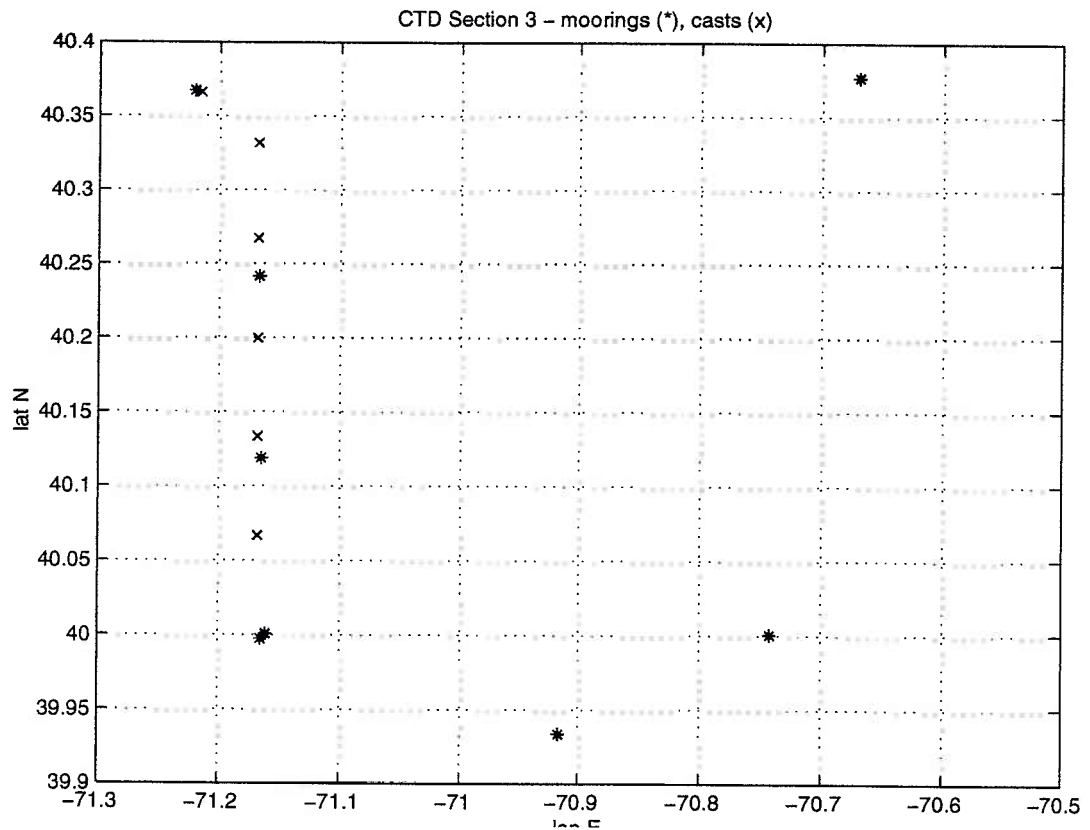


FIGURE 73. CTD section 3 - Western leg on Feb 15

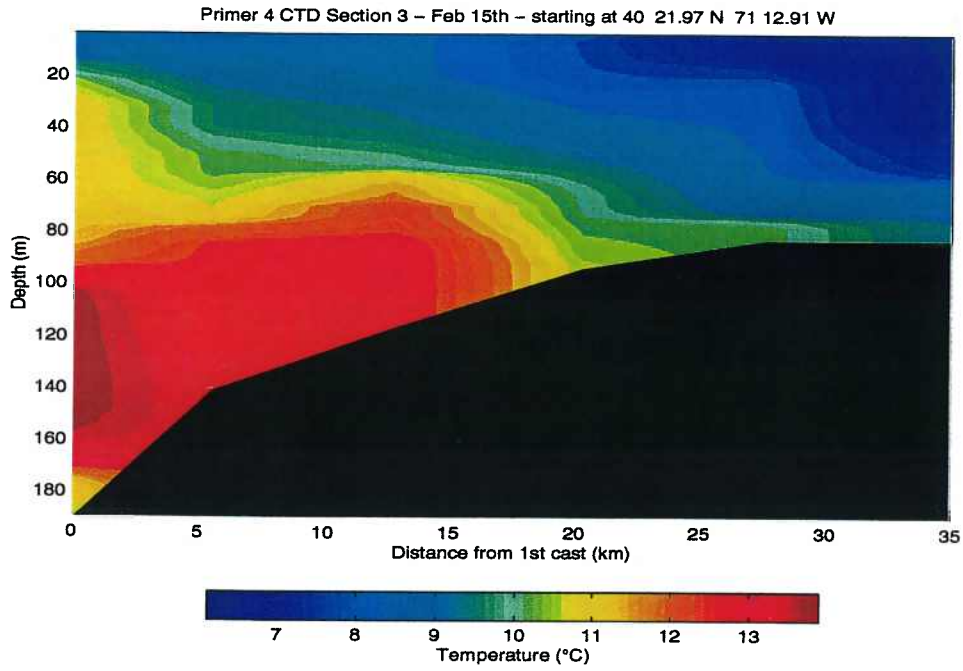


FIGURE 74. CTD temperatures for section 3 on Feb 15 at 2200 hrs (Z).

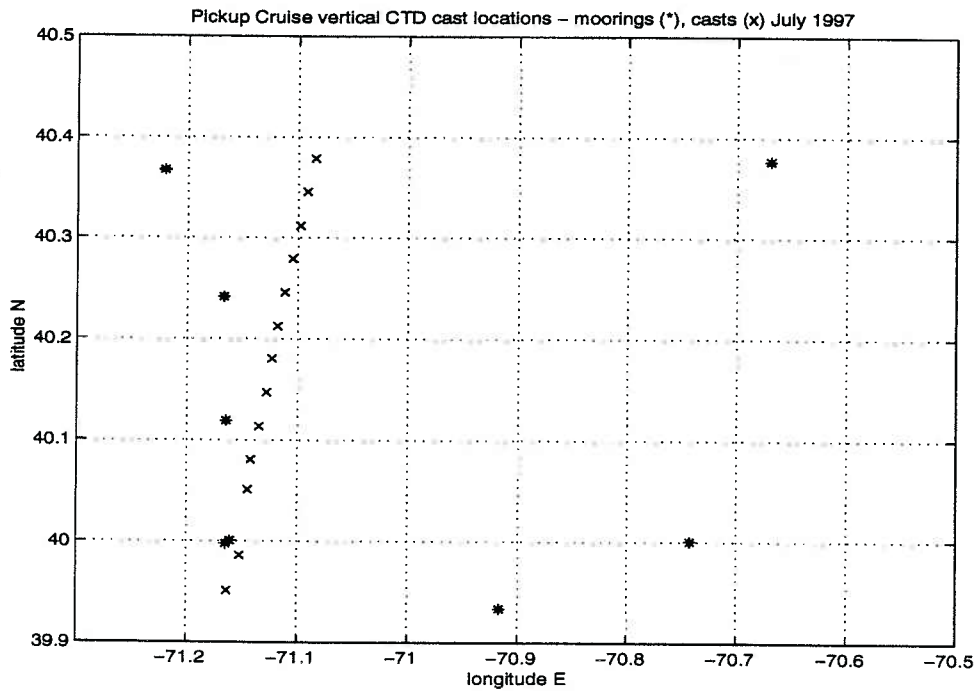


FIGURE 75. CTD locations from July pickup cruise.

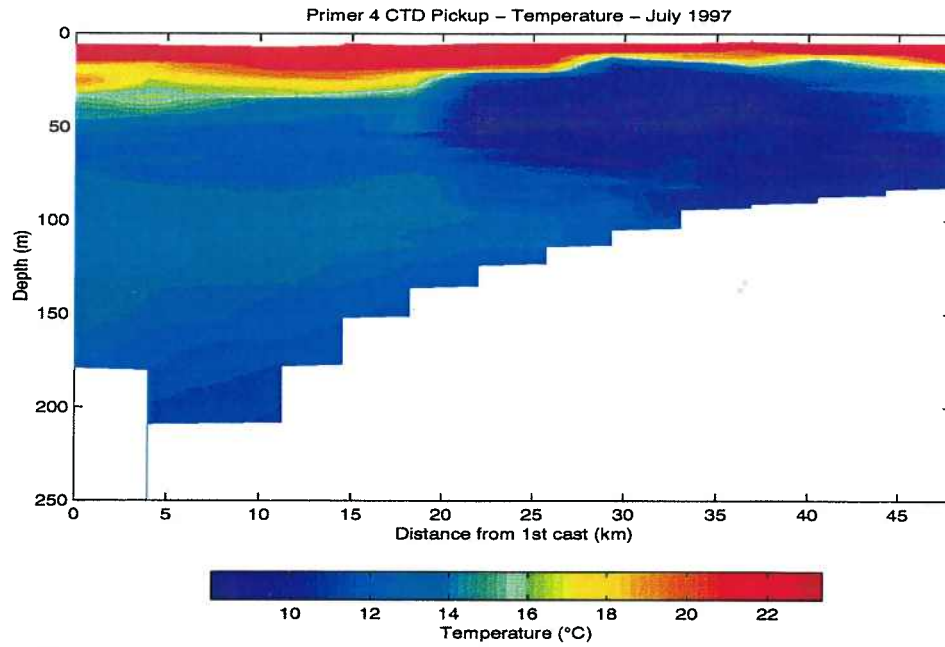


FIGURE 76. CTD pickup temperatures.

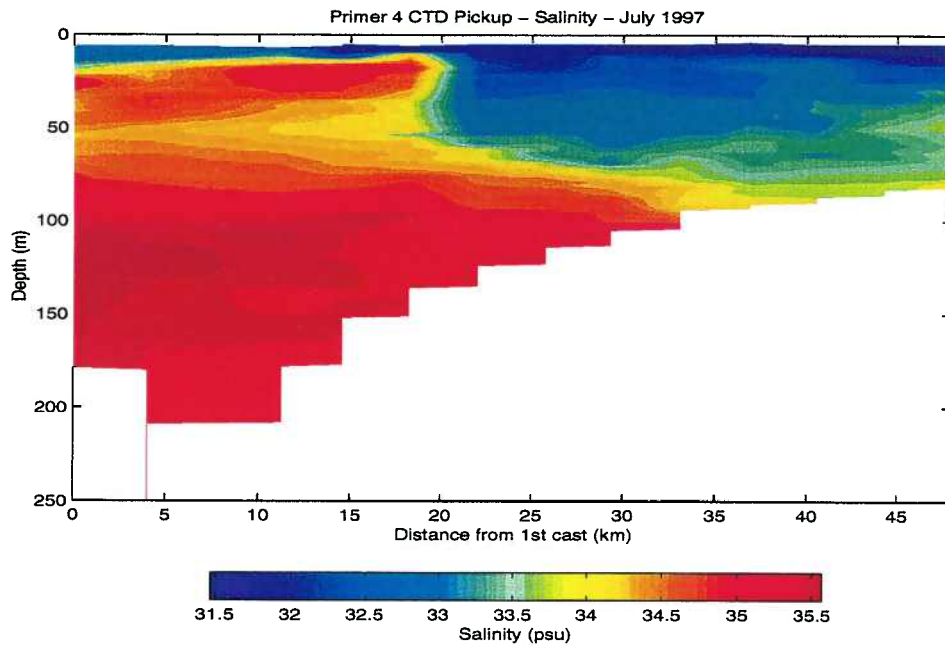


FIGURE 77. Pickup CTD salinity.

2.10 Shipboard met/navigation/chirp data

The R/V Endeavor had many on-board sensors which acquired data continuously throughout the cruise; Chirp sonar data, meteorological data, and ship navigation data. The chirp sonar data was on continuously except when acoustically interrogating instruments. We have 15 DAT tapes that contain approximately 27 chirp data files on each. Windspeed (fig 78) and chirp sonar bottom depths (fig 79) were used as initial data confirmation. All hull mounted instruments (adcp, chirp,...) have a nominal depth of 5 meters.

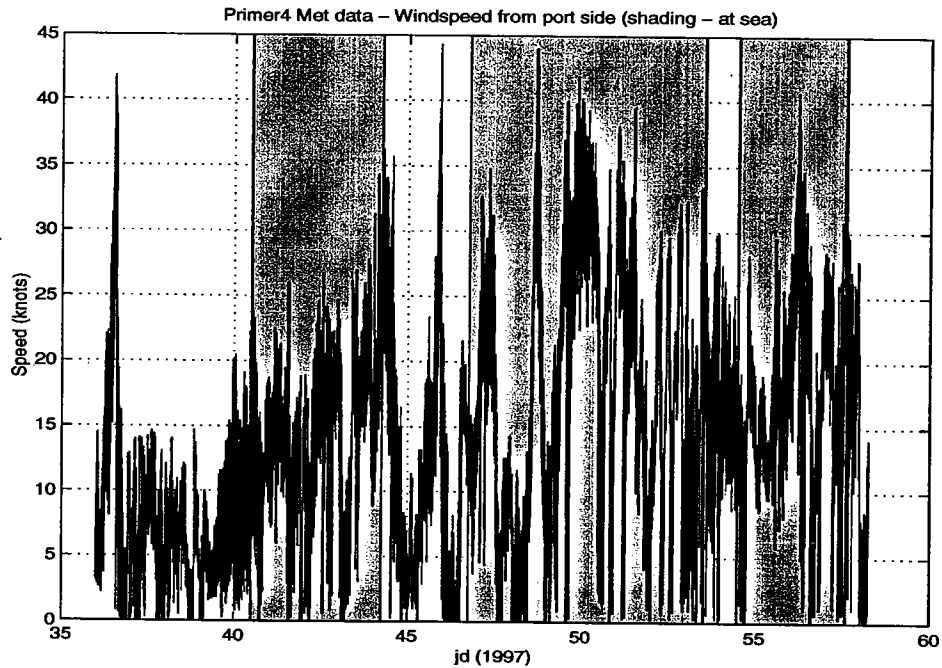


FIGURE 78. Windspeed from R/V Endeavor met data. Shading shows days at sea.

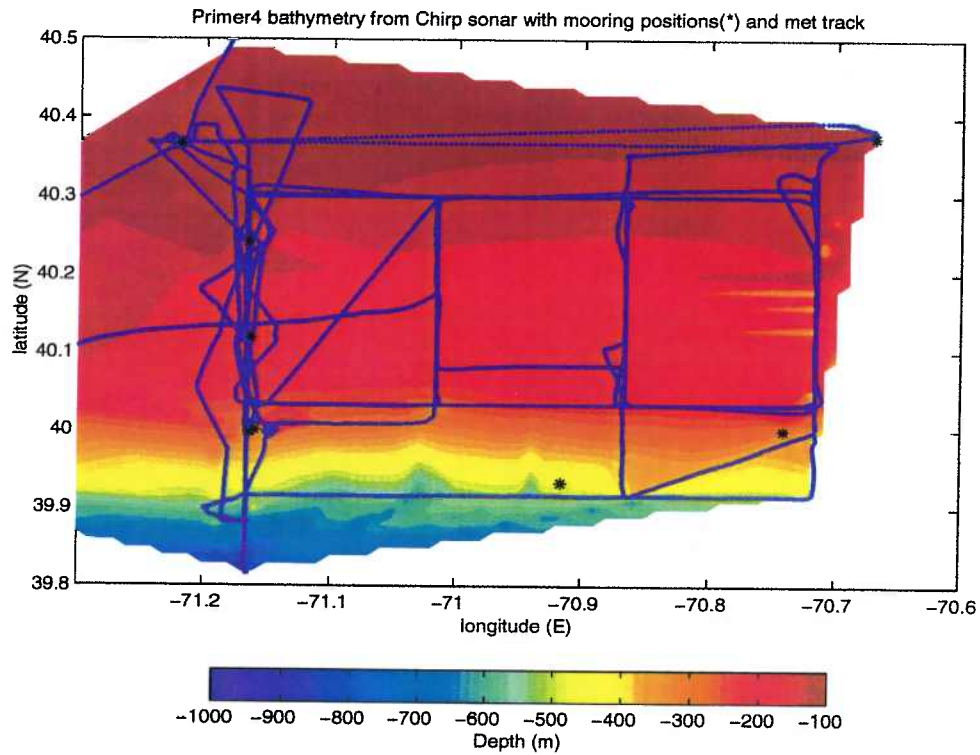


FIGURE 79. Bathymetry acquired by Chirp sonar.

Met data and format:

Sample frequency = 60 seconds
 New file frequency = 24 hours
 Data item count = 30

- 1) MAGELLAN 5000DX GPS
Magellan GPS UTC of fix
- 2) MAGELLAN 5000DX GPS
Magellan GPS north latitude
- 3) MAGELLAN 5000DX GPS
Magellan GPS west longitude
- 4) MAGELLAN 5000DX GPS
Magellan GPS quality indicator
 0 = fix not available or invalid
 1 = non differential fix
 2 = differential fix
- 5) MAGELLAN 5000DX GPS
Magellan GPS speed made good in knots

- 6) MAGELLAN 5000DX GPS
Magellan GPS course made good in degrees true
- 7) TRIMBLE NAVTRAC GPS
Trimble GPS UTC of fix
- 8) TRIMBLE NAVTRAC GPS
Trimble GPS north latitude
- 9) TRIMBLE NAVTRAC GPS
Trimble GPS west longitude
- 10) TRIMBLE NAVTRAC GPS
Trimble GPS quality indicator
0 = fix not available or invalid
1 = non differential fix
2 = differential fix
- 11) TRIMBLE NAVTRAC GPS
Trimble GPS speed made good in knots
- 12) TRIMBLE NAVTRAC GPS
Trimble GPS course made good in degrees true
- 13) RM YOUNG TRANSLATOR
Port apparent wind speed in knots
- 14) RM YOUNG TRANSLATOR
Starboard apparent wind speed in knots
- 15) RM YOUNG TRANSLATOR
Port apparent wind azimuth in degrees
- 16) RM YOUNG TRANSLATOR
Starboard apparent wind azimuth in degrees
- 17) RM YOUNG TRANSLATOR
Air temperature in degrees C
- 18) RM YOUNG TRANSLATOR
Relative humidity in percent
- 19) RM YOUNG TRANSLATOR
Barometric pressure in millibars
- 20) RM YOUNG TRANSLATOR
Sea surface temperature in degrees C measured at transducer
well 5 meters below surface
- 21) EDO SPEED LOG
EDO speed log forward velocity with respect to water or bottom
- 22) RM YOUNG TRANSLATOR

Eppley PIR, long wave radiation in W/m^2
SN = 30606F3, calibrated 20 December 1995

23) RM YOUNG TRANSLATOR
Eppley PSP, global sun and sky radiation (short wave) in W/m^2
SN = 30600F3, calibrated 20 December 1995

24) EDO SPEED LOG
EDO speed log depth below transducer in meters

25) GYRO 1 \$HEHDT 1
Gyro 1 (starboard), ship's head in degrees true

26) GYRO 2 \$HEHDT 1
Gyro 2 (port), ship's head in degrees true

27) RM YOUNG TRANSLATOR
Sea surface temperature in degrees C measured at ship's
hull 1 meter below surface

28) CHIRP SONAR
EG&G Chirp Sonar depth below transducer in meters

29) EDO SPEED LOG
EDO speed log tracking mode
A = water track
V = bottom track

30) System Time 0
Decimal yearday

2.11 Satellite IR images

Throughout the entire cruise, satellite sea surface temperature data was collected to get spatial information on mesoscale oceanographic features. WHOI's Mike Caruso collected satellite sea surface temperature information from the National Oceanic and Atmospheric Administration (NOAA) Coastwatch Program while the experiment was in progress. A warm core ring (figs 80-82) remained within the study area for the duration and influenced much of the data we collected.

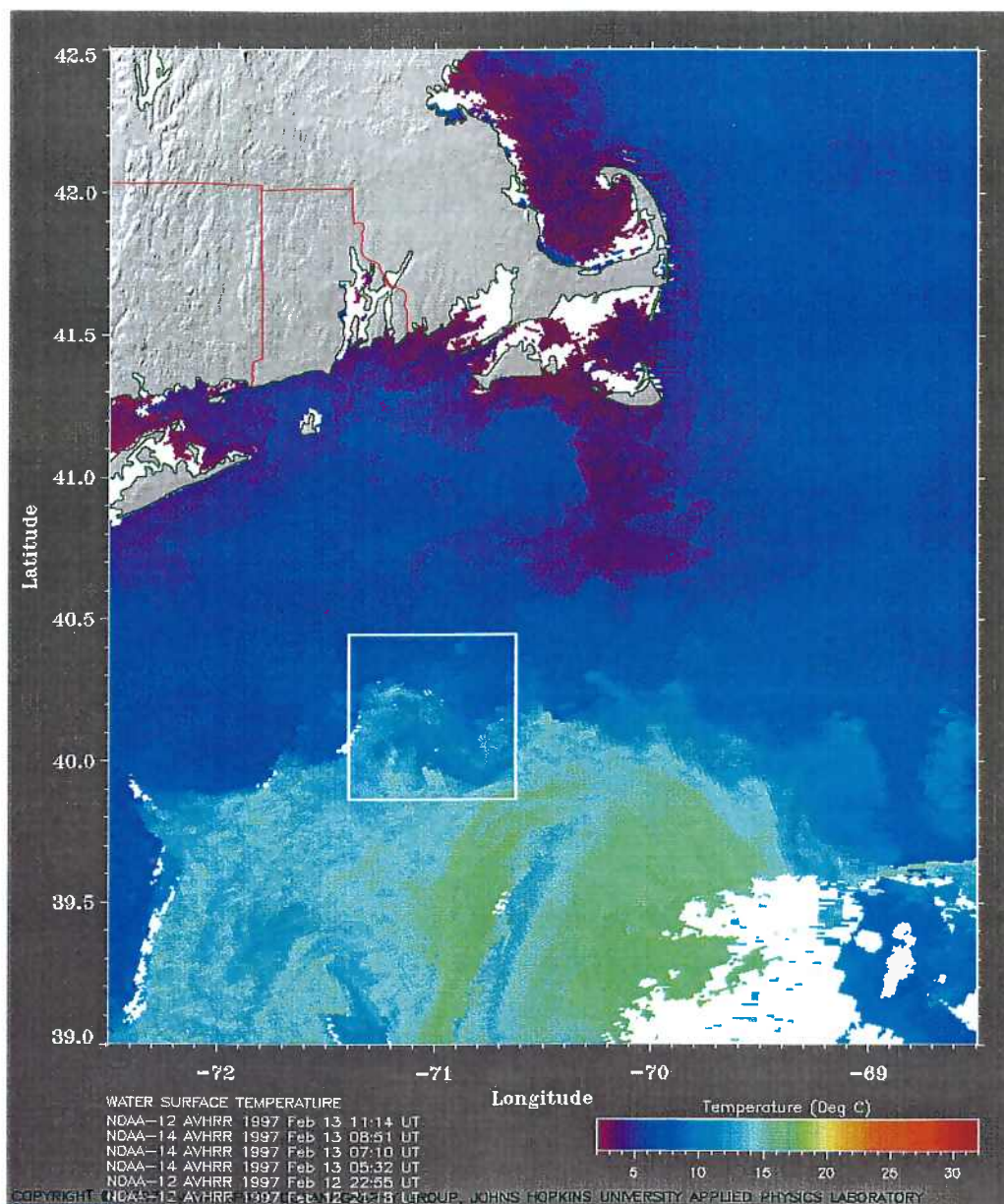


FIGURE 80. Sea surface temperature for Feb 13th from the Ocean Remote Sensing Group at John Hopkins University. The box indicates the Primer area of study.

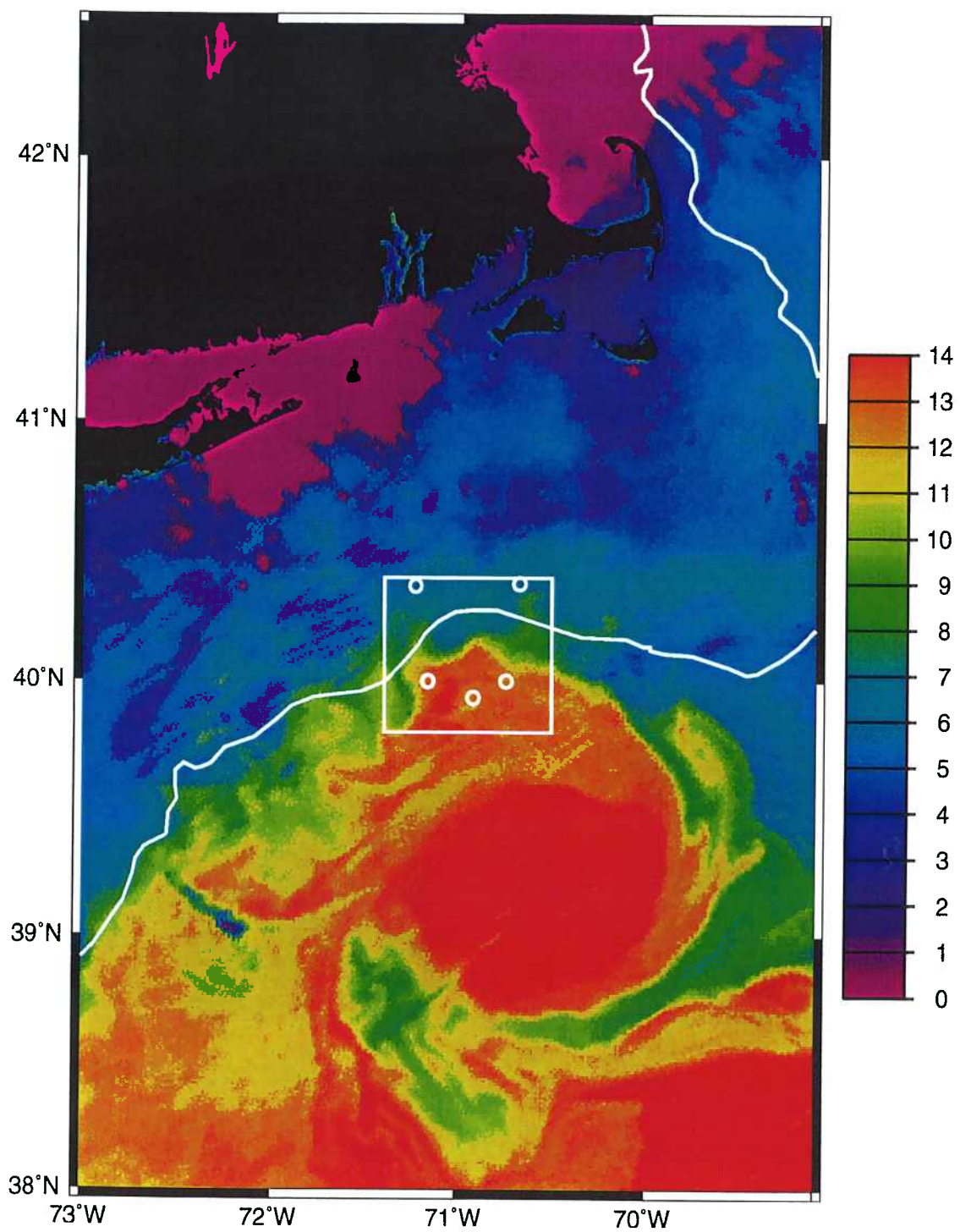


FIGURE 81. Sea surface temperature for Feb 18th courtesy of Mike Caruso. White line is the 100 meter isobath and the box is the area of study. The circles mark the acoustic moorings. Temperature color levels are in degrees C.

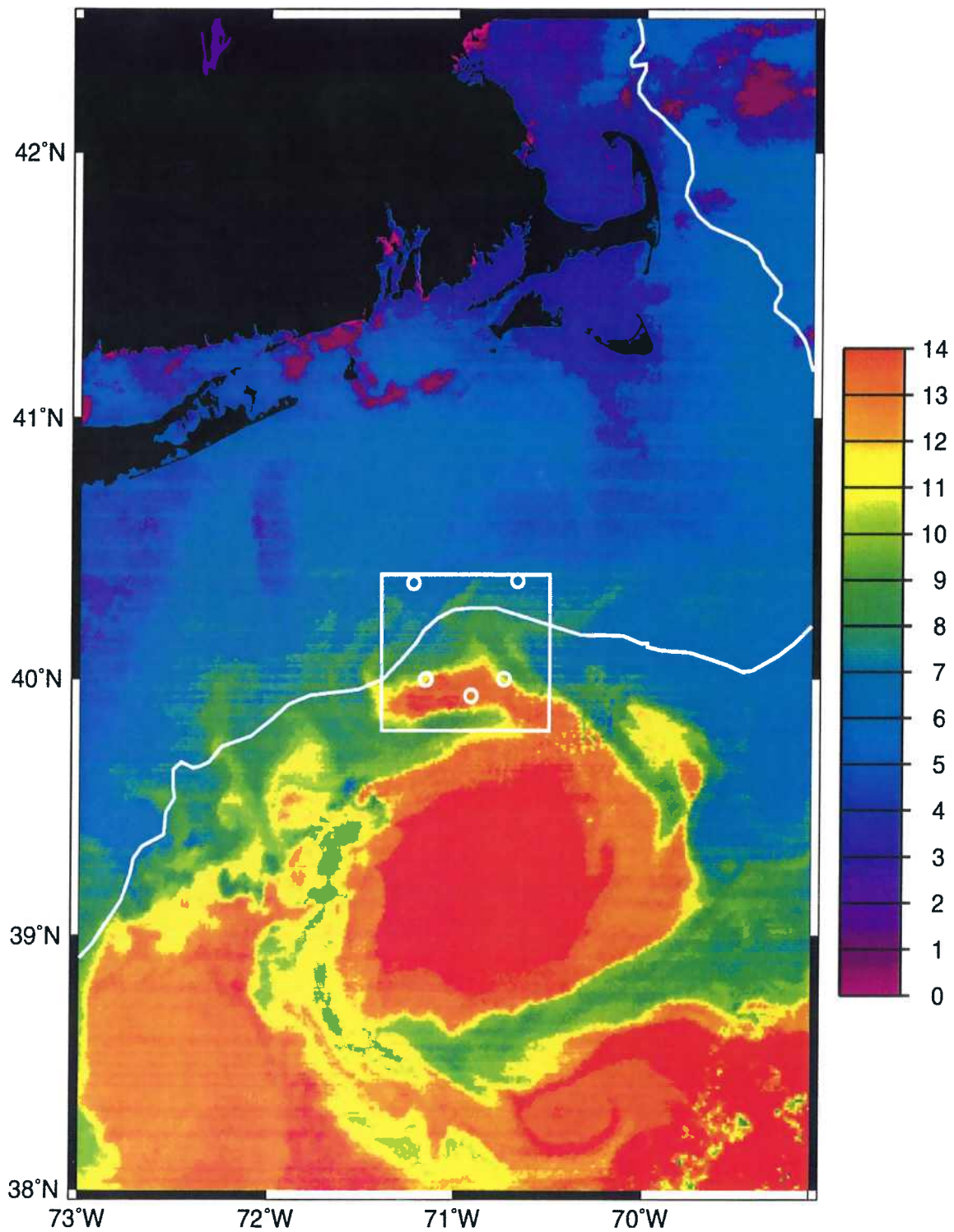


FIGURE 82. Sea Surface temperature for Feb 21st courtesy of Mike Caruso. The white line is the 100 meter isobath and the box is the area of study. The circles mark the acoustic moorings. Temperature color levels are in degrees C.

3.0 Field Deployment And Observations

3.1 Weather

The weather at the Primer4 site was typical of February in the North Atlantic - cold and windy. All deck work was conducted during windows of opportunity when the winds were light and the seas were comparatively low.

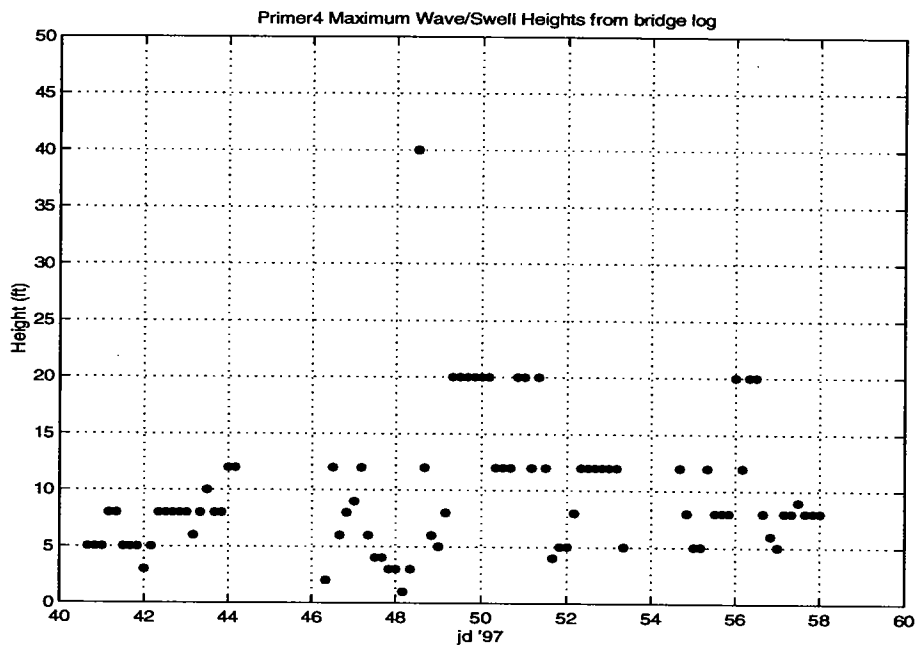


FIGURE 83. Maximum wave/swell heights observed from the R/V Endeavor bridge.

TABLE 46. Primer4 weather and sea state taken from bridge log.

| date | local time (hrs) | weather | visibility (miles) | Wind dir. (deg N) | wind speed (knots) | sea direction (deg N) | sea height (ft) | swell direction (deg N) | swell height (ft) | Air temp (deg F) | water temp (deg F) |
|--------|------------------|---------|--------------------|-------------------|--------------------|-----------------------|-----------------|-------------------------|-------------------|------------------|--------------------|
| Feb 9 | 1600 | bc | 12 | 45.0 | 11-16 | 45.0 | 3-5 | 45.0 | 3 | 35 | 31 |
| Feb 9 | 2000 | bc | 12 | 67.5 | 11-16 | 45.0 | 3-5 | 225.0 | 5 | 35 | 30 |
| Feb 9 | 2400 | clr | 12 | 22.5 | 17-21 | 45.0 | 3-5 | 45.0 | 5 | 36 | 32 |
| | | | | | | | | | | | |
| Feb 10 | 0400 | bc | 12 | 67.5 | 17-21 | 67.5 | 5-8 | 67.5 | 5 | 36 | 32 |
| Feb 10 | 0800 | bc | 12 | 67.5 | 17-21 | 67.5 | 5-8 | 67.5 | 5 | 38 | 32 |
| Feb 10 | 1200 | bc | 12 | 45 | 11-16 | 45 | 3-5 | 45 | 4 | 38 | 34 |
| Feb 10 | 1600 | bc | 12 | 45 | 11-16 | 45 | 3-5 | 45 | 4 | 38 | 34 |
| Feb 10 | 2000 | ovc | 12 | 67.5 | 7-10 | 45 | 3-5 | 45 | 3 | 39 | 34 |
| Feb 10 | 2400 | ovc | 12 | 67.5 | 7-10 | 67.5 | 1-3 | 45 | 2 | 38 | 32 |
| | | | | | | | | | | | |
| Feb 11 | 0400 | sno | 10 | 315 | 11-16 | 315 | 3-5 | 22.5 | 2 | 33 | 32 |
| Feb 11 | 0800 | sno | 2 | 315 | 19-25 | 315 | 5-8 | 315 | 4 | 34 | 33 |
| Feb 11 | 1200 | ovc | 8 | 315 | 22-27 | 315 | 5-8 | 315 | 5 | 38 | 32 |
| Feb 11 | 1600 | ovc | 8 | 315 | 17-21 | 315 | 5-8 | 315 | 5 | 36 | 35 |
| Feb 11 | 2000 | ovc | 8 | 315 | 17-21 | 315 | 5-8 | 315 | 6 | 37 | 36 |
| Feb 11 | 2400 | ovc | 10 | 315 | 11-16 | 315 | 5-8 | 315 | 5 | 40 | 34 |
| | | | | | | | | | | | |
| Feb 12 | 0400 | ovc | 8 | var | 7-10 | 315 | 1-3 | 315 | 6 | 39 | 36 |
| Feb 12 | 0800 | ovc | 6 | 135 | 17-21 | 135 | 3-5 | 315 | 8 | 38 | 33 |
| Feb 12 | 1200 | ovc | 8 | 135 | 17-21 | 135 | 5-8 | 292.5 | 10 | 36 | 32 |
| Feb 12 | 1600 | ovc | 8 | 135 | 17-21 | 135 | 5-8 | 292.5 | 8 | 38 | 36 |
| Feb 12 | 2000 | ovc | 7 | 135 | 17-21 | 135 | 5-8 | 135 | 8 | 38 | 37 |
| Feb 12 | 2400 | ovc | 8 | 135 | 22-27 | 135 | 8-12 | 135 | 10 | 38 | 34 |
| | | | | | | | | | | | |
| Feb 13 | 0400 | bc | 10 | 112.5 | 22-27 | 112.5 | 8-12 | 112.5 | 7 | 34 | 30 |
| | | | | | | | | | | | |
| Feb 15 | 0800 | fair | 1 | 90 | 11-16 | 90 | <1 | 90 | 2 | 38 | 38 |
| Feb 15 | 1200 | ovc | 5 | 67.5 | 11-16 | 67.5 | 8-12 | 90 | 10 | 40 | 40 |
| Feb 15 | 1600 | bc | 8 | 67.5 | 11-16 | 67.5 | 3-5 | 90 | 6 | 42 | 41 |
| Feb 15 | 2000 | bc | 8 | 67.5 | 22-27 | 67.5 | 5-8 | 45 | 8 | 43 | 40 |
| Feb 15 | 2400 | bc | 8 | 45 | 22-27 | 45 | 5-8 | 45 | 9 | 44 | 38 |
| | | | | | | | | | | | |

TABLE 46. Primer4 weather and sea state taken from bridge log.

| date | local time (hrs) | weather | visibility (miles) | Wind dir. (deg N) | wind speed (knots) | sea direction (deg N) | sea height (ft) | swell direction (deg N) | swell height (ft) | Air temp (deg F) | water temp (deg F) |
|--------|------------------|---------|--------------------|-------------------|--------------------|-----------------------|-----------------|-------------------------|-------------------|------------------|--------------------|
| Feb 16 | 0400 | bc | 10 | 67.5 | 22-27 | 67.5 | 8-12 | 67.5 | 8 | 38 | 36 |
| Feb 16 | 0800 | bc | 10 | 45 | 11-16 | 45 | 3-5 | 67.5 | 6 | 35 | 30 |
| Feb 16 | 1200 | bc | 12 | 112.5 | 7-10 | 45 | 1-3 | 90 | 4 | 40 | 36 |
| Feb 16 | 1600 | clr | 12 | 315 | 4-6 | 45 | 1-3 | 45 | 4 | 38 | 36 |
| Feb 16 | 2000 | clr | 12 | 225 | 7-10 | 270 | 1-3 | 45 | 3 | 34 | 31 |
| Feb 16 | 2400 | rain | 2 | 90 | 7-10 | 270 | 1-3 | 0 | 3 | 38 | 36 |
| | | | | | | | | | | | |
| Feb 17 | 0400 | ovc | 6 | 45 | 4-6 | 45 | <1 | var | 0 | 36 | 36 |
| Feb 17 | 0800 | ovc | 8 | 45 | 14-19 | 45 | 1-3 | 45 | 2 | 38 | 37 |
| Feb 17 | 1200 | ovc | 8 | 0 | 34-40 | 0 | 20-40 | 0 | 15 | 35 | 33 |
| Feb 17 | 1600 | ovc | 6 | 0 | 17-21 | 0 | 8-12 | 0 | 10 | 32 | 30 |
| Feb 17 | 2000 | bc | 10 | 45 | 4-6 | 45 | <1 | 45 | 6 | 32 | 29 |
| Feb 17 | 2400 | bc | 12 | 90 | 7-10 | 90 | 1-3 | 90 | 5 | 34 | 32 |
| | | | | | | | | | | | |
| Feb 18 | 0400 | bc | 12 | 135 | 22-27 | 135 | 5-8 | 135 | 6 | 36 | 34 |
| Feb 18 | 0800 | bc | 12 | 112.5 | 22-27 | 112.5 | 13-20 | 112.5 | 10 | 45 | 41 |
| Feb 18 | 1200 | clr | 12 | 112.5 | 22-27 | 112.5 | 13-20 | 112.5 | 12 | 42 | 40 |
| Feb 18 | 1600 | bc | 12 | 112.5 | 34-40 | 112.5 | 13-20 | 112.5 | 14 | 48 | 44 |
| Feb 18 | 2000 | b | 12 | 157.5 | 34-40 | 157.5 | 13-20 | 157.5 | 14 | 51 | 45 |
| Feb 18 | 2400 | bc | 12 | 112.5 | 22-27 | 112.5 | 13-20 | 112.5 | 15 | 53 | 48 |
| | | | | | | | | | | | |
| Feb 19 | 0400 | bc | 10 | 135 | 22-27 | 135 | 13-20 | 135 | 12 | 50 | 46 |
| Feb 19 | 0800 | bc | 10 | 112.5 | 22-27 | 112.5 | 8-12 | 135 | 12 | 51 | 49 |
| Feb 19 | 1200 | ovc | 8 | 135 | 22-27 | 135 | 8-12 | 135 | 12 | 46 | 40 |
| Feb 19 | 1600 | ovc | 8 | 135 | 22-27 | 135 | 8-12 | 135 | 10 | 48 | 46 |
| Feb 19 | 2000 | bc | 10 | 157.5 | 22-27 | 157.5 | 13-20 | 135 | 12 | 51 | 50 |
| Feb 19 | 2400 | ovc | 10 | 112.5 | 41-47 | 112.5 | 13-20 | 112.5 | 14 | 58 | 55 |
| | | | | | | | | | | | |
| Feb 20 | 0400 | bc | 12 | 67.5 | 22-27 | 90 | 8-12 | 112.5 | 7 | 49 | 47 |
| Feb 20 | 0800 | bc | 10 | 45 | 22-27 | 45 | 13-20 | 45 | 8 | 42 | 39 |
| Feb 20 | 1200 | clr | 12 | 22.5 | 22-27 | 45 | 8-12 | 45 | 8 | 42 | 40 |
| Feb 20 | 1600 | bc | 12 | 45 | 4-6 | 45 | 1-3 | 45 | 4 | 39 | 36 |
| Feb 20 | 2000 | bc | 12 | 202.5 | 11-16 | 225 | 3-5 | 45 | 3 | 38 | 36 |
| Feb 20 | 2400 | clr | 12 | 202.5 | 17-21 | 225 | 3-5 | 45 | 4 | 44 | 41 |
| | | | | | | | | | | | |

TABLE 46. Primer4 weather and sea state taken from bridge log.

| date | local time (hrs) | weather | visibility (miles) | Wind dir. (deg N) | wind speed (knots) | sea direction (deg N) | sea height (ft) | swell direction (deg N) | swell height (ft) | Air temp (deg F) | water temp (deg F) |
|--------|------------------|---------|--------------------|-------------------|--------------------|-----------------------|-----------------|-------------------------|-------------------|------------------|--------------------|
| Feb 21 | 0400 | ovc | 10 | 135 | 17-21 | 135 | 5-8 | 135 | 5 | 43 | 42 |
| Feb 21 | 0800 | bc | 10 | 157.5 | 22-27 | 157.5 | 8-12 | 157.5 | 5 | 52 | 51 |
| Feb 21 | 1200 | ovc | 8 | 157.5 | 22-27 | 157.5 | 8-12 | 157.5 | 8 | 54 | 54 |
| Feb 21 | 1600 | ovc | 6 | 157.5 | 22-27 | 157.5 | 8-12 | 157.5 | 8 | 52 | 51 |
| Feb 21 | 2000 | bc | 6 | 157.5 | 22-27 | 157.5 | 8-12 | 157.5 | 10 | 53 | 53 |
| Feb 21 | 2400 | ovc | 6 | 157.5 | 22-27 | 157.5 | 8-12 | 157.5 | 10 | 50 | 50 |
| | | | | | | | | | | | |
| Feb 22 | 0400 | fog | 0 | 135 | 22-27 | 135 | 8-12 | 135 | 6 | 48 | 48 |
| Feb 22 | 0800 | fog | 0 | 157.5 | 22-27 | 157.5 | 3-5 | 157.5 | 3 | 46 | 45 |
| | | | | | | | | | | | |
| Feb 23 | 1600 | bc | 12 | 112.5 | 22-27 | 135 | 8-12 | 112.5 | 5 | 36 | 34 |
| Feb 23 | 2000 | ovc | 12 | 112.5 | 22-27 | 112.5 | 5-8 | 112.5 | 5 | 38 | 36 |
| Feb 23 | 2400 | clr | 12 | 90 | 22-27 | 90 | 3-5 | 90 | 4 | 40 | 40 |
| | | | | | | | | | | | |
| Feb 24 | 0400 | bc | 12 | 90 | 11-16 | 90 | 3-5 | 90 | 4 | 42 | 42 |
| Feb 24 | 0800 | bc | 10 | 45 | 22-27 | 45 | 8-12 | 45 | 5 | 44 | 43 |
| Feb 24 | 1200 | bc | 12 | 67.5 | 17-21 | 67.5 | 5-8 | 67.5 | 5 | 42 | 40 |
| Feb 24 | 1600 | clr | 10 | 67.5 | 22-27 | 67.5 | 5-8 | 67.5 | 6 | 40 | 40 |
| Feb 24 | 2000 | bc | 12 | 90 | 17-21 | 90 | 5-8 | 90 | 6 | 44 | 43 |
| Feb 24 | 2400 | bc | 12 | 90 | 22-27 | 90 | 13-20 | 90 | 12 | 40 | 40 |
| | | | | | | | | | | | |
| Feb 25 | 0400 | ovc | 10 | 45 | 22-27 | 45 | 8-12 | 67.5 | 8 | 34 | 34 |
| Feb 25 | 0800 | clr | 10 | 45 | 25-31 | 45 | 13-20 | 67.5 | 12 | 28 | 28 |
| Feb 25 | 1200 | clr | 10 | 0 | 17-21 | 0 | 13-20 | 45 | 10 | 36 | 36 |
| Feb 25 | 1600 | bc | 12 | 0 | 17-21 | 0 | 5-8 | 45 | 6 | 30 | 30 |
| Feb 25 | 2000 | bc | 12 | 45 | 11-16 | 45 | 3-5 | 45 | 6 | 30 | 28 |
| Feb 25 | 2400 | bc | 12 | 67.5 | 11-16 | 45 | 3-5 | 45 | 5 | 30 | 28 |
| | | | | | | | | | | | |
| Feb 26 | 0400 | bc | 12 | 135 | 17-21 | 135 | 5-8 | 135 | 7 | 39 | 36 |
| Feb 26 | 0800 | bc | 12 | 135 | 19-24 | 135 | 5-8 | 135 | 8 | 43 | 41 |
| Feb 26 | 1200 | bc | 12 | 90 | 22-27 | 90 | 5-8 | 90 | 9 | 46 | 42 |
| Feb 26 | 1600 | bc | 10 | 135 | 22-27 | 135 | 5-8 | 135 | 6 | 43 | 41 |
| Feb 26 | 2000 | ovc | 12 | 135 | 17-21 | 135 | 5-8 | 135 | 6 | 45 | 43 |
| Feb 26 | 2400 | rain | 4 | 135 | 11-16 | 135 | 5-8 | 135 | 6 | 46 | 44 |

3.2 Summer pickups

Because the weather hindered deck work towards the end of the cruise, only the SE acoustic tomography mooring was recovered during the scheduled part of the Primer4 experiment. The other acoustic sources remained in the water until they could be picked up later. The Central tomography transceiver mooring was recovered in late March, during the MOMAX experiment. The 224 Hz source and the bottom section of the 400 Hz source from the SW site were picked up the following July.

4.0 Acknowledgements

This project was funded by the Office of Naval Research under ONR grant N00014-98-10413 to the Woods Hole Oceanographic Institution. This support is gratefully acknowledged.

We would like to thank our colleagues, John Kemp, Nick Witzell, John Bouthiette, Mike Caruso, Jim Miller, Ching-Sang Chiu, Chris Miller, Marla Stone, Betsy Doherty, Frank Bahr, Ellen Levy, Paul Fucile, Jerry Dean, and Al Morton who all helped make this experiment a success and this report possible.

We would also like to thank the entire crew of the R/V Endeavor for all their help and support.

And last, but not least, we would like to thank the Capt'n Kidd restaurant for being open during our port calls.

5.0 Appendices

5.1 cruise participants

Leg 1 Feb. 9 -> Feb. 13

| Name | Affiliation | Assignment |
|---------------------|-------------|---------------------------|
| Glen Gawarkiewicz | WHOI-PO | SeaSoar (Chief Scientist) |
| Jim Lynch | WHOI-AOPE | Tomography Moorings |
| John Kemp | WHOI-AOPE | Tomography Moorings |
| Keith Von der Heydt | WHOI-AOPE | Tomography Moorings |
| Arthur Newhall | WHOI-AOPE | Tomography Moorings |
| Warren Witzell | WHOI-AOPE | Tomography Moorings |
| Brian Sperry | WHOI-AOPE | Tomography Moorings |
| Scott WorriLOW | WHOI-PO | ADCP Moorings |
| Jim Miller | URI | Tomography Moorings |
| Gopu Potty | URI | Tomography Moorings |
| John Bouthillette | WHOI-AOPE | Tomography Moorings |
| Jan Szelag | URI | CTD, Marine Tech |

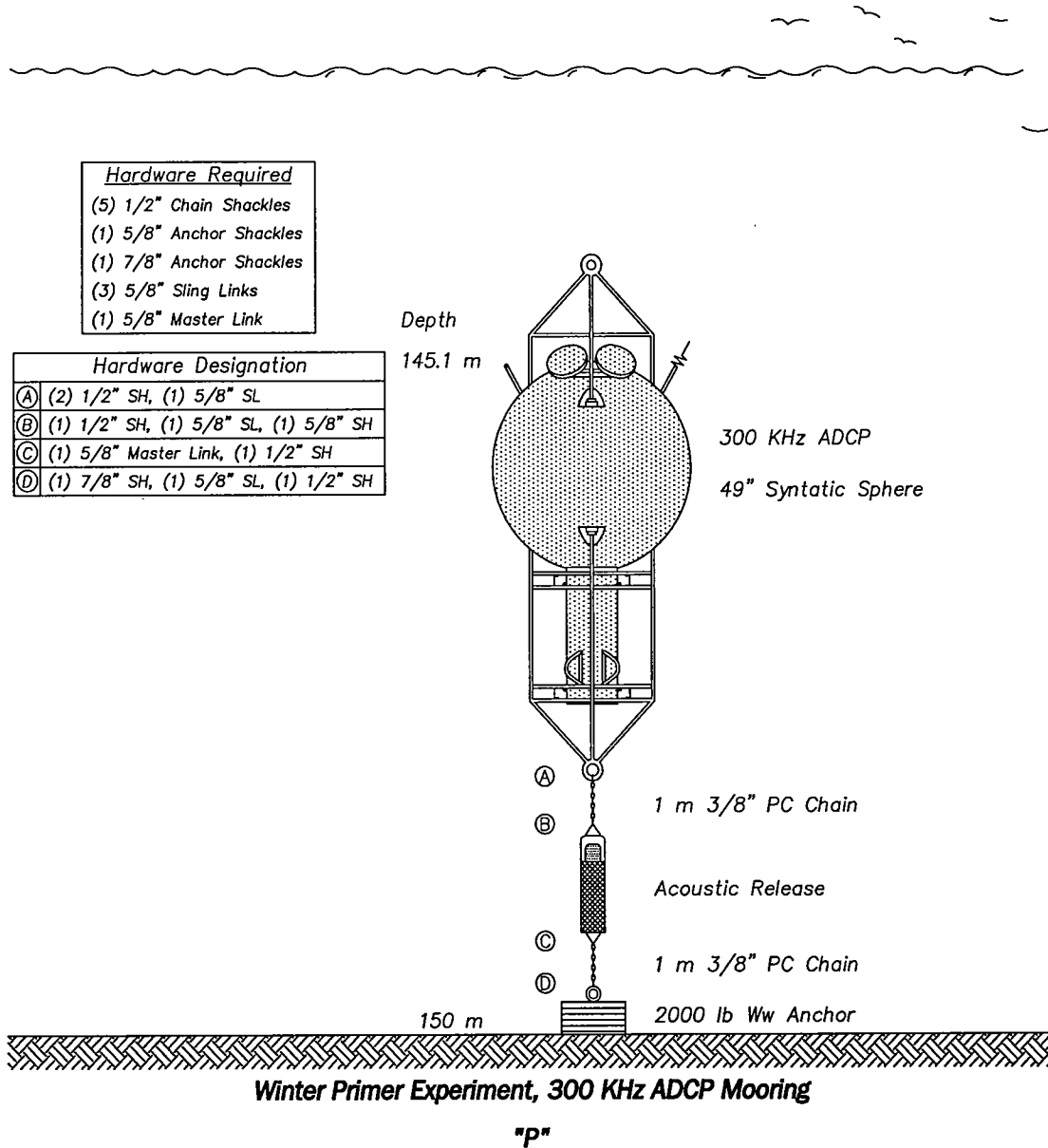
Leg 2 Feb. 15 -> Feb. 21

| Name | Affiliation | Assignment |
|-------------------|-------------|---------------------------|
| Glen Gawarkiewicz | WHOI-PO | SeaSoar (Chief Scientist) |
| Frank Bahr | WHOI-PO | SeaSoar |
| Paul Fucile | WHOI-PO | SeaSoar |
| Jerry Dean | WHOI-PO | SeaSoar |
| Al Gordon | WHOI-PO | SeaSoar |
| Ellen Levy | WHOI-PO | SeaSoar |
| Wayne Leslie | Harvard | Modelling |
| Pat Haley | Harvard | Modelling |
| Jim Lynch | WHOI-AOPE | Tomography Moorings |
| John Bouthillette | WHOI-AOPE | Tomography Moorings |
| Arthur Newhall | WHOI-AOPE | Tomography Moorings |
| Warren Witzell | WHOI-AOPE | Tomography Moorings |
| Jim Miller | URI | Acoustics - sus |
| Gopu Potty | URI | Acoustics - sus |

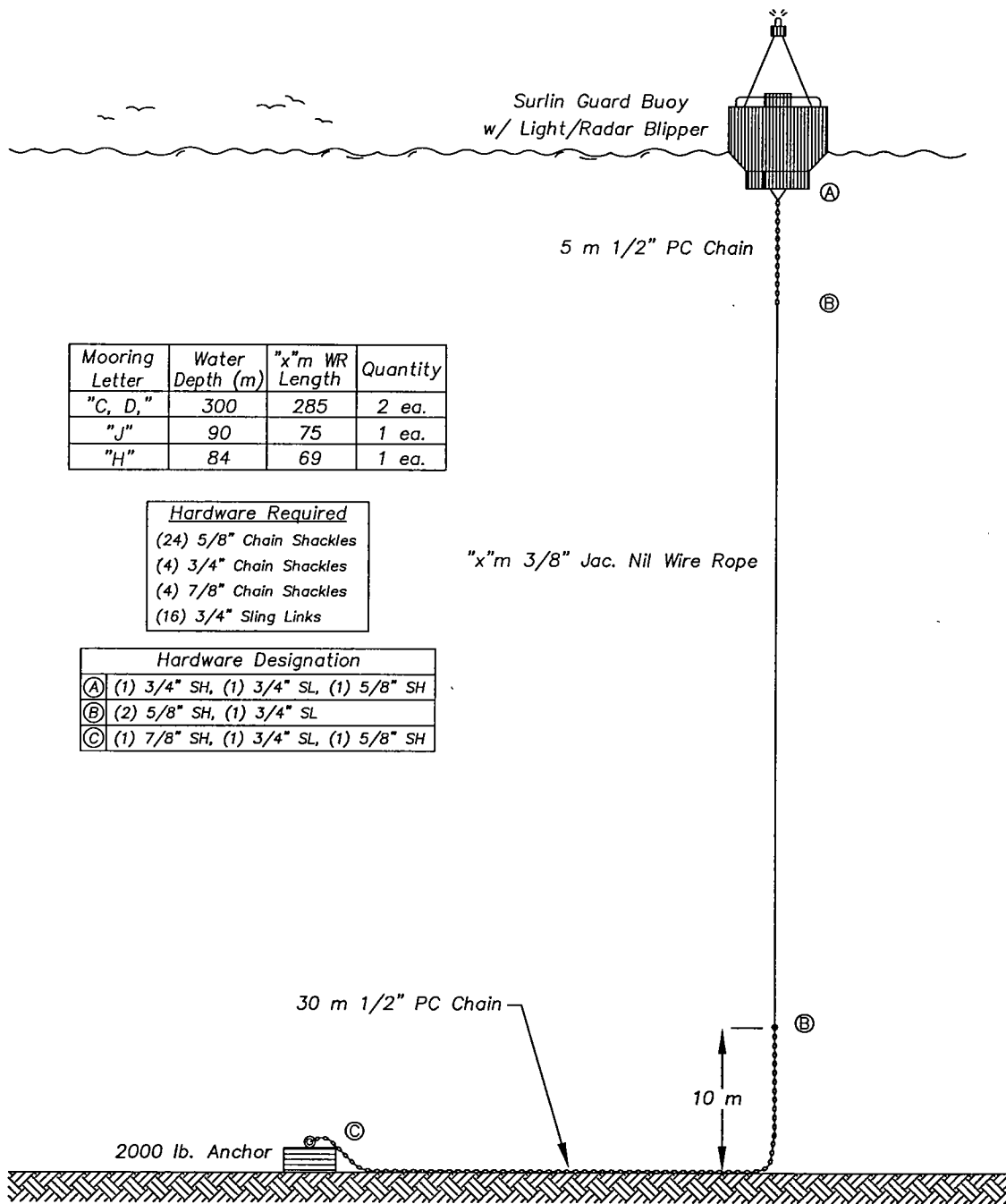
Leg 3 Feb. 22 -> Feb 27

| Name | Affiliation | Assignment |
|-------------------|----------------------|-----------------------|
| Glen Gawarkiewicz | WHOI-PO | CTD (Chief Scientist) |
| Terry McKee | WHOI-PO | CTD |
| Jennifer Pryztup | Univ. Of S. Carolina | CTD |
| Jim Lynch | WHOI-AOPE | Tomography Moorings |
| John Kemp | WHOI-AOPE | Tomography Moorings |
| John Bouthillette | WHOI-AOPE | Tomography Moorings |
| Arthur Newhall | WHOI-AOPE | Tomography Moorings |
| Warren Witzell | WHOI-AOPE | Tomography Moorings |
| Jim Miller | URI | Tomography Moorings |
| Gopu Potty | URI | Tomography Moorings |
| Ching-Sang Chiu | NPS | Tomography Moorings |
| Marla Stone | NPS | Tomography Moorings |
| John Colosi | WHOI-AOPE | CTD |
| Jan Szelag | URI | CTD |
| Martin Visbek | LDEO | CTD |
| Manfred Mensch | LDEO | Tracers |

5.2 Predeployment mooring drawings



Betsy Doherty date: 07/09/98
 file: WNTPRMR rev: 01/15/97
 John Kemp Sheet 1 of 12



Surlin Guard Buoy
w/ Light/Radar Blipper

5 m 1/2" PC Chain

| Mooring Letter | Water Depth (m) | "x"m WR Length | Quantity |
|----------------|-----------------|----------------|----------|
| "C, D," | 300 | 285 | 2 ea. |
| "J" | 90 | 75 | 1 ea. |
| "H" | 84 | 69 | 1 ea. |

Hardware Required
 (24) 5/8" Chain Shackles
 (4) 3/4" Chain Shackles
 (4) 7/8" Chain Shackles
 (16) 3/4" Sling Links

"x"m 3/8" Jac. Nil Wire Rope

| Hardware Designation | |
|----------------------|---------------------------------------|
| (A) | (1) 3/4" SH, (1) 3/4" SL, (1) 5/8" SH |
| (B) | (2) 5/8" SH, (1) 3/4" SL |
| (C) | (1) 7/8" SH, (1) 3/4" SL, (1) 5/8" SH |

30 m 1/2" PC Chain

10 m

2000 lb. Anchor

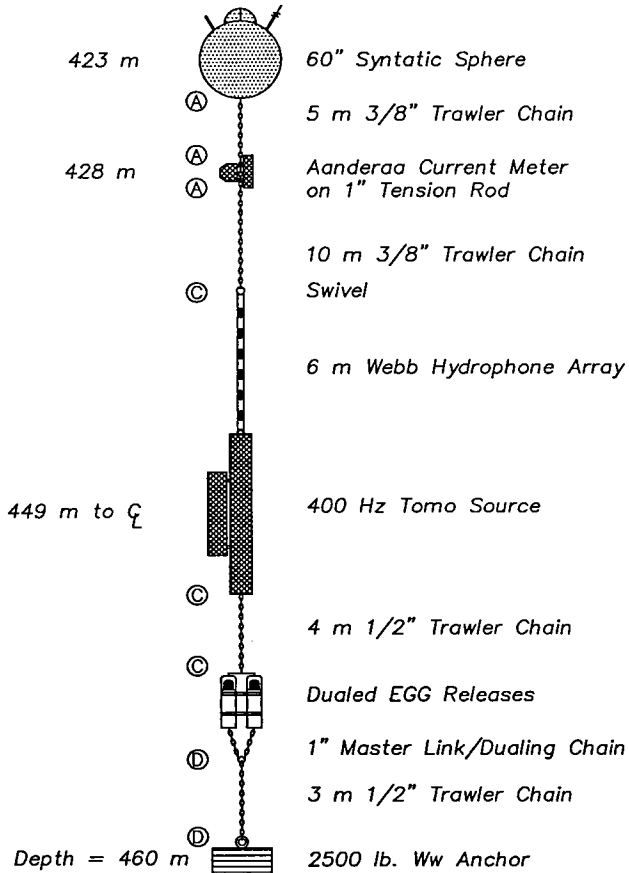
Winter Primer Experiment, Guard Buoy Moorings (4 Required)

"C, D, H, J"

Betsy Doherty date: 07/09/98
 file: WINTERPRM rev: 01/15/97
 John Kemp Sheet 2 of 12

| Hardware Required | |
|-------------------|----------------------|
| (11) | 1/2" Chain Shackles |
| (3) | 5/8" Anchor Shackles |
| (1) | 3/4" Anchor Shackles |
| (2) | 7/8" Anchor Shackles |
| (8) | 5/8" Sling Links |
| (1) | 1" Master Link |

| Hardware Designation | |
|----------------------|--|
| (A) | (2) 1/2" SH, (1) 5/8" SL |
| (B) | (1) 1" Master Link, (1) 3/4" SH, (1) 1/2" SH |
| (C) | (1) 1/2" SH, (2) 5/8" SL, (3) 5/8" SH |
| (D) | (1) 1/2" SH, (1) 5/8" SL, (1) 7/8" SH |



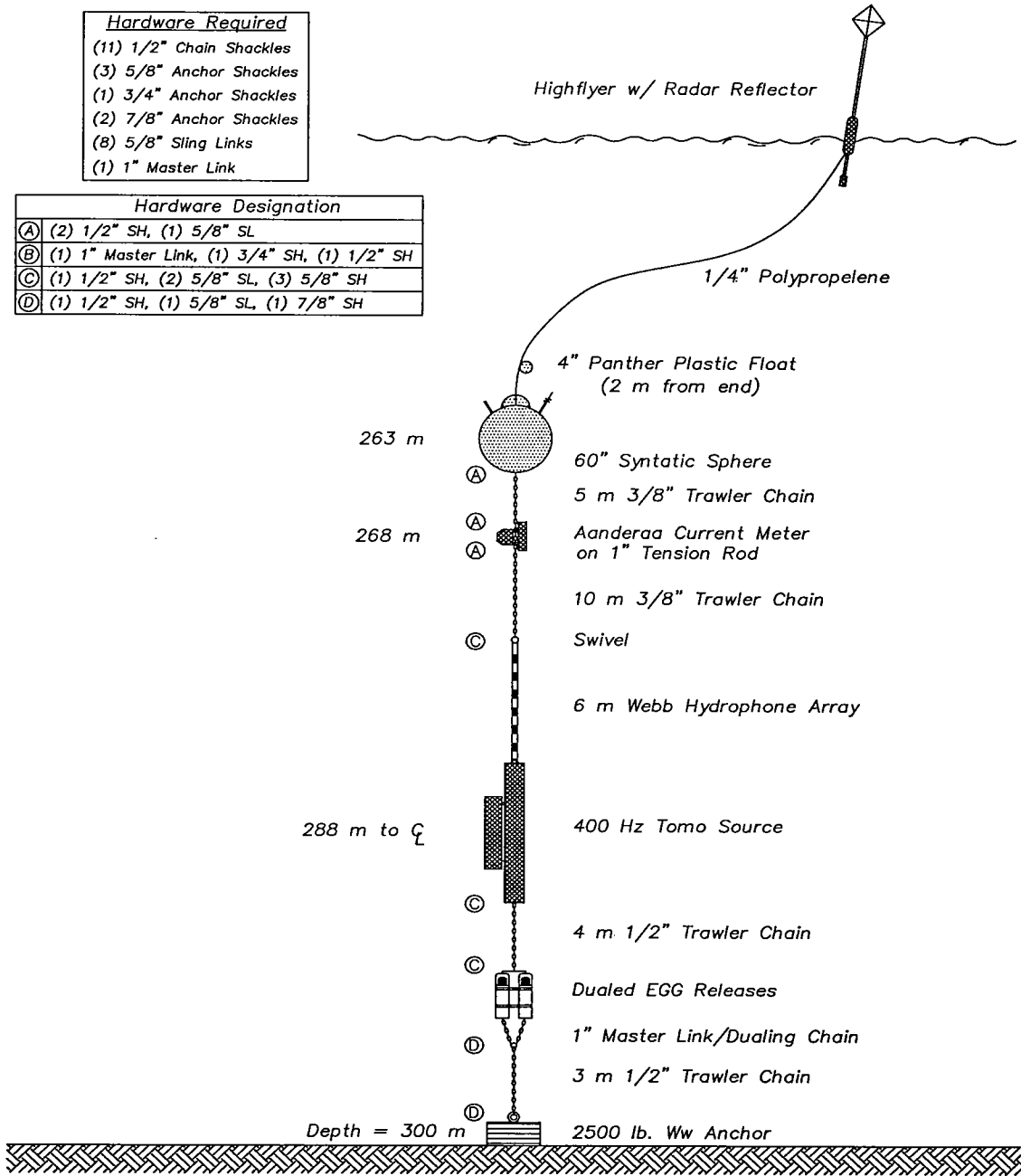
Winter Primer Experiment, 400Hz Tomo Source Mooring, Central

Betsy Doherty date: 07/08/96
file: WY100PRM1 rev: 01/15/97
John Kemp Sheet 3 of 12

"F"

| Hardware Required | |
|-------------------|----------------------|
| (11) | 1/2" Chain Shackles |
| (3) | 5/8" Anchor Shackles |
| (1) | 3/4" Anchor Shackles |
| (2) | 7/8" Anchor Shackles |
| (8) | 5/8" Sling Links |
| (1) | 1" Master Link |

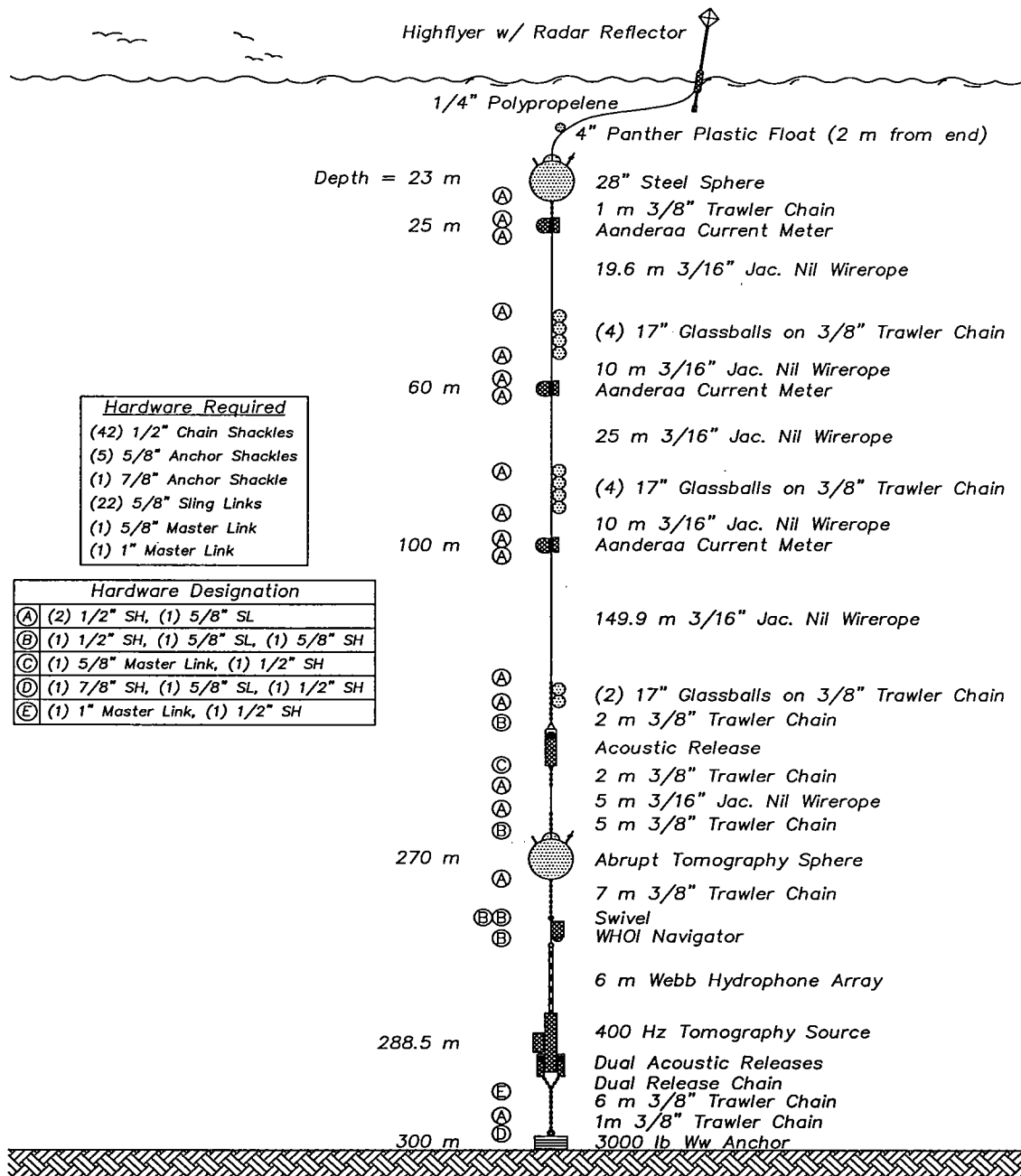
| Hardware Designation | |
|----------------------|--|
| (A) | (2) 1/2" SH, (1) 5/8" SL |
| (B) | (1) 1" Master Link, (1) 3/4" SH, (1) 1/2" SH |
| (C) | (1) 1/2" SH, (2) 5/8" SL, (3) 5/8" SH |
| (D) | (1) 1/2" SH, (1) 5/8" SL, (1) 7/8" SH |



Winter Primer Experiment, 400Hz Tomo Source Mooring, SE

"E"

Betsy Doherty date: 07/09/96
 file: WINTERPRM rev: 01/15/97
 John Kemp Sheet: 4 of 12



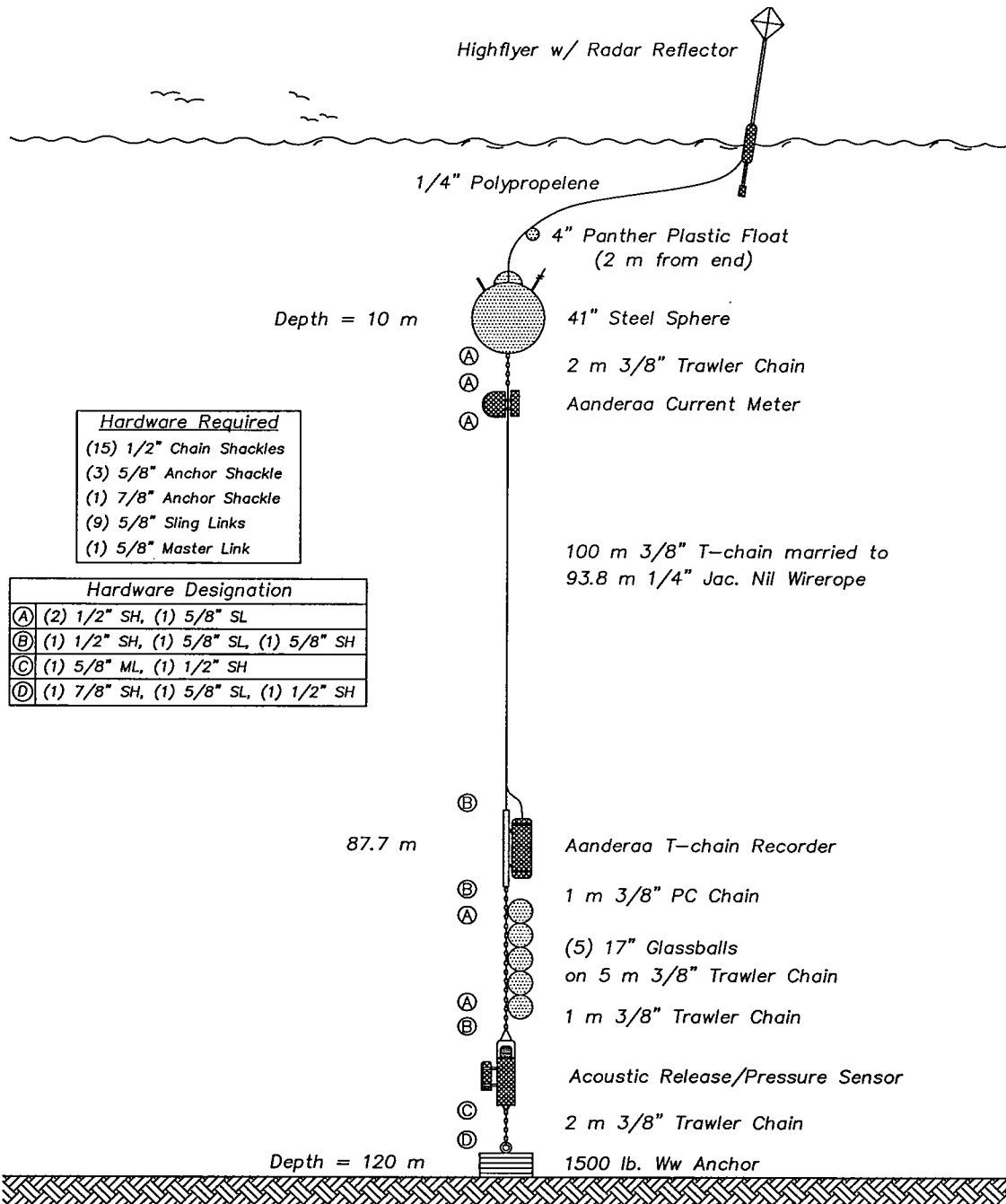
Hardware Required
 (42) 1/2" Chain Shackles
 (5) 5/8" Anchor Shackles
 (1) 7/8" Anchor Shackle
 (22) 5/8" Sling Links
 (1) 5/8" Master Link
 (1) 1" Master Link

| Hardware Designation | |
|----------------------|---------------------------------------|
| (A) | (2) 1/2" SH, (1) 5/8" SL |
| (B) | (1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH |
| (C) | (1) 5/8" Master Link, (1) 1/2" SH |
| (D) | (1) 7/8" SH, (1) 5/8" SL, (1) 1/2" SH |
| (E) | (1) 1" Master Link, (1) 1/2" SH |

Winter Primer Experiment, Thermistor Mooring, 400 Hz Tomography Source, SW

Datsey Doherty date: 07/08/96
 Rec: WINTPRMR rev: 01/15/97
 John Kemp Sheet 5 of 12

"B"



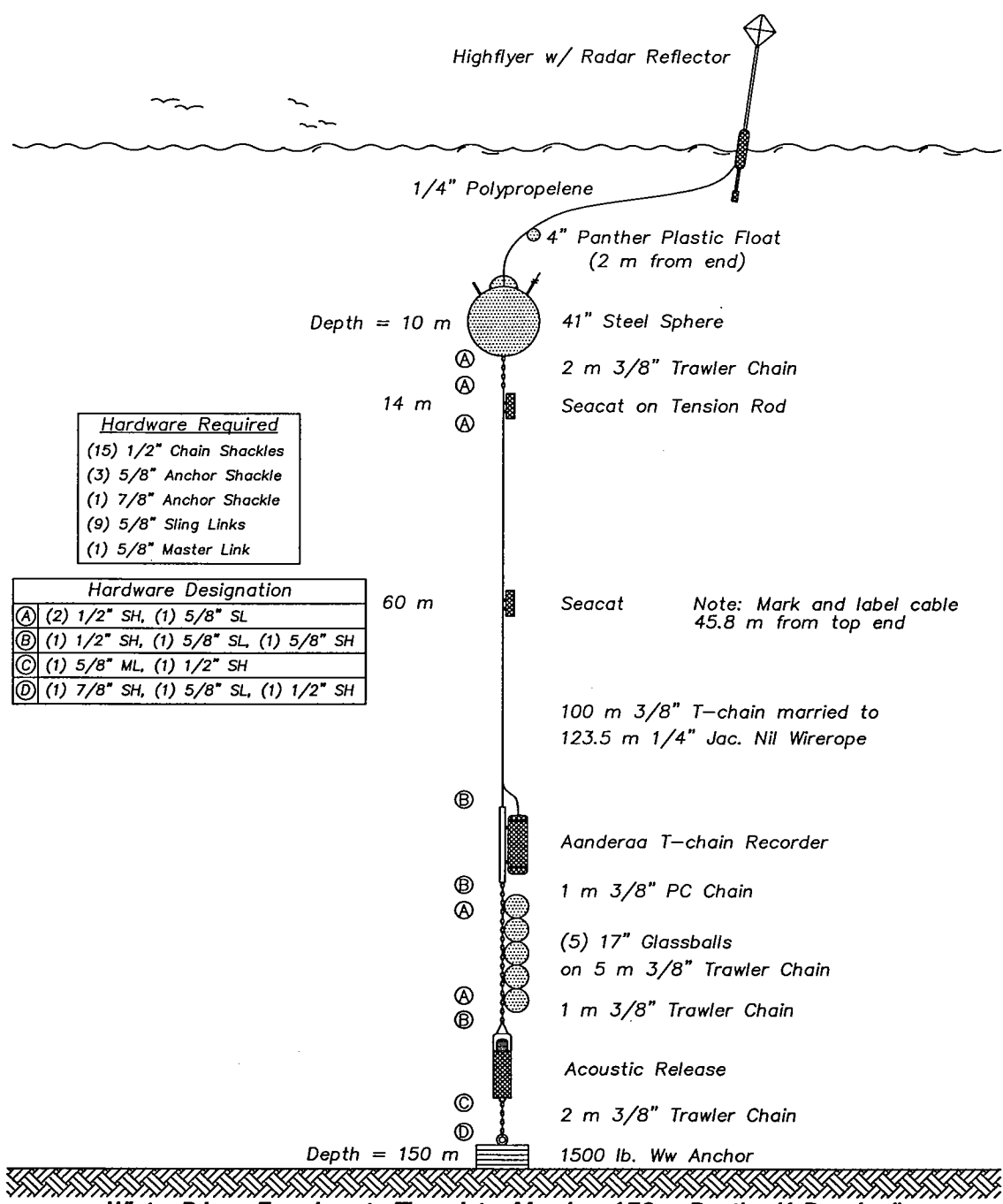
- Hardware Required**
- (15) 1/2" Chain Shackles
 - (3) 5/8" Anchor Shackles
 - (1) 7/8" Anchor Shackle
 - (9) 5/8" Sling Links
 - (1) 5/8" Master Link

| Hardware Designation | |
|----------------------|---------------------------------------|
| (A) | (2) 1/2" SH, (1) 5/8" SL |
| (B) | (1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH |
| (C) | (1) 5/8" ML, (1) 1/2" SH |
| (D) | (1) 7/8" SH, (1) 5/8" SL, (1) 1/2" SH |

Winter Primer Experiment, Thermistor Mooring, 120 m Depth, (1 Required)

Betsy Doherty date: 07/08/96
 file: WTPRIMR rev: 01/15/97
 John Kemp Sheet 6 of 12

"N"



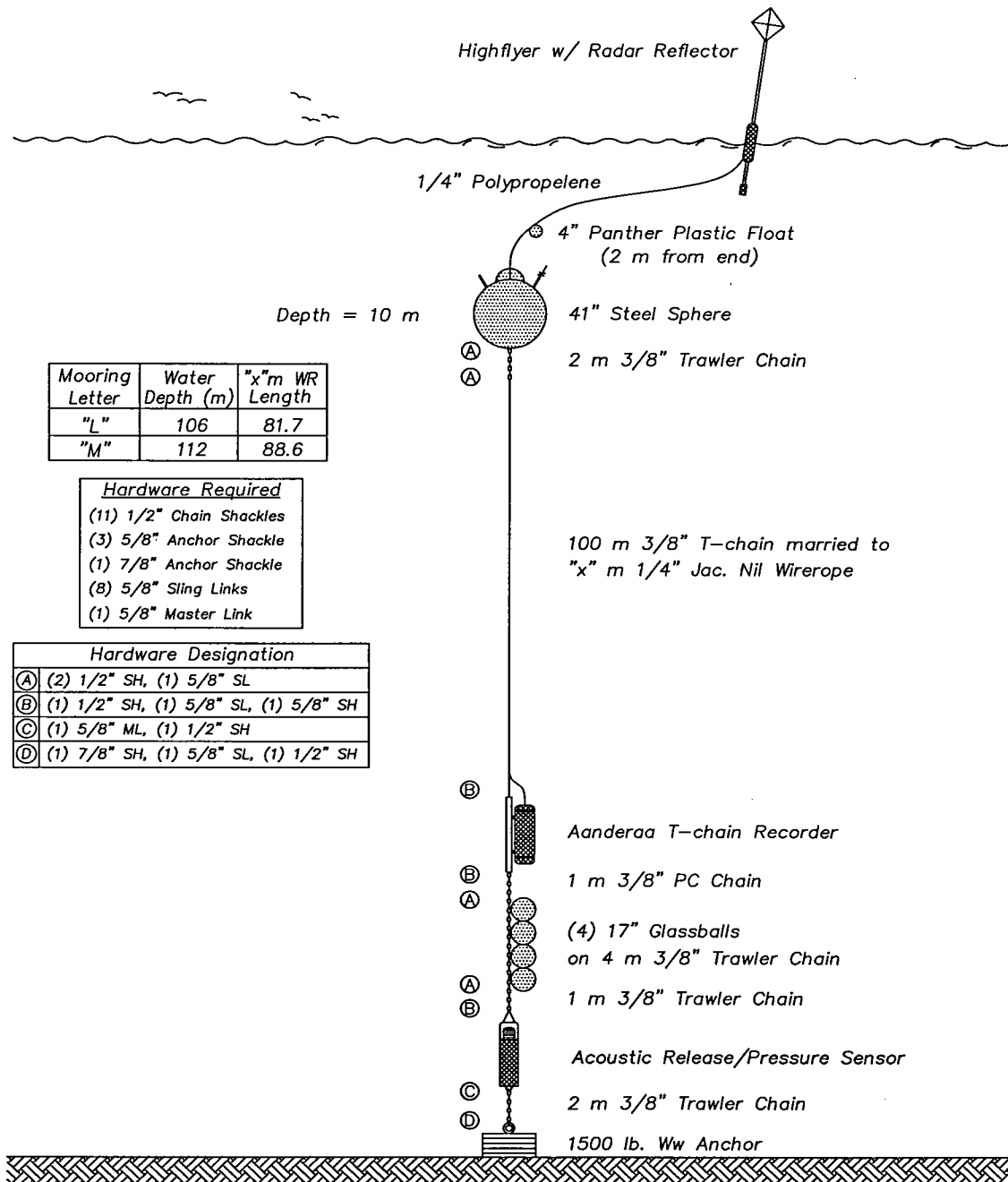
Hardware Required
 (15) 1/2" Chain Shackles
 (3) 5/8" Anchor Shackle
 (1) 7/8" Anchor Shackle
 (9) 5/8" Sling Links
 (1) 5/8" Master Link

| Hardware Designation | |
|----------------------|---------------------------------------|
| (A) | (2) 1/2" SH, (1) 5/8" SL |
| (B) | (1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH |
| (C) | (1) 5/8" ML, (1) 1/2" SH |
| (D) | (1) 7/8" SH, (1) 5/8" SL, (1) 1/2" SH |

Winter Primer Experiment, Thermistor Mooring, 150 m Depth, (1 Required)

Betsy Doherty date: 07/09/96
 #1: WNTPRM1 rev: 01/15/97
 John Kemp Sheet 7 of 12

"0"



Depth = 10 m

| Mooring Letter | Water Depth (m) | "x" m WR Length |
|----------------|-----------------|-----------------|
| "L" | 106 | 81.7 |
| "M" | 112 | 88.6 |

- Hardware Required**
- (11) 1/2" Chain Shackles
 - (3) 5/8" Anchor Shackle
 - (1) 7/8" Anchor Shackle
 - (8) 5/8" Sling Links
 - (1) 5/8" Master Link

| Hardware Designation | |
|----------------------|---------------------------------------|
| (A) | (2) 1/2" SH, (1) 5/8" SL |
| (B) | (1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH |
| (C) | (1) 5/8" ML, (1) 1/2" SH |
| (D) | (1) 7/8" SH, (1) 5/8" SL, (1) 1/2" SH |

100 m 3/8" T-chain married to "x" m 1/4" Jac. Nil Wire rope

Aanderaa T-chain Recorder

1 m 3/8" PC Chain

(4) 17" Glassballs on 4 m 3/8" Trawler Chain

1 m 3/8" Trawler Chain

Acoustic Release/Pressure Sensor

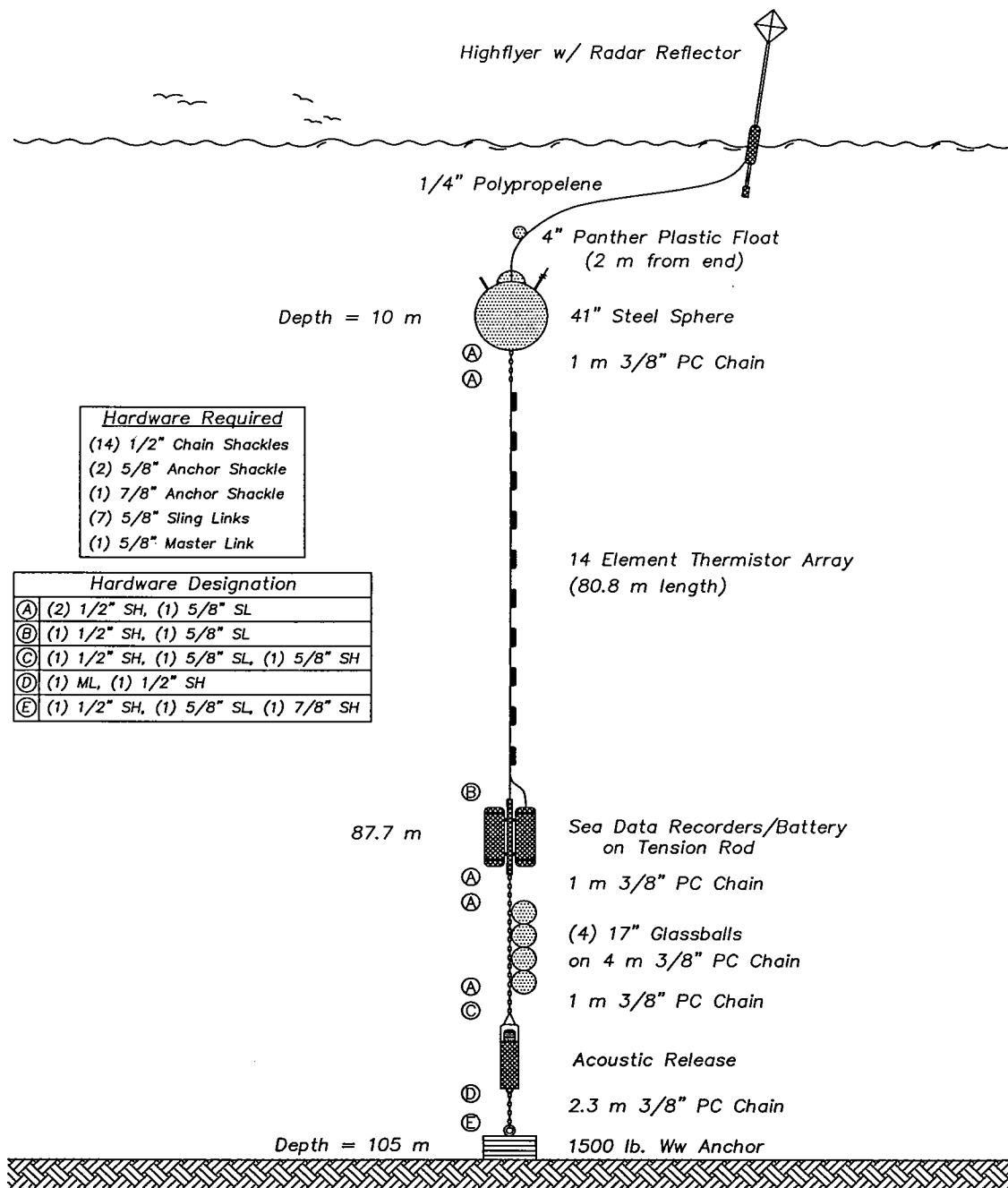
2 m 3/8" Trawler Chain

1500 lb. Ww Anchor

Winter Primer Experiment, Thermistor Mooring, (2 Required)

Betsy Doherty date: 07/09/96
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 John Kemp Sheet 8 of 12

"L, M"



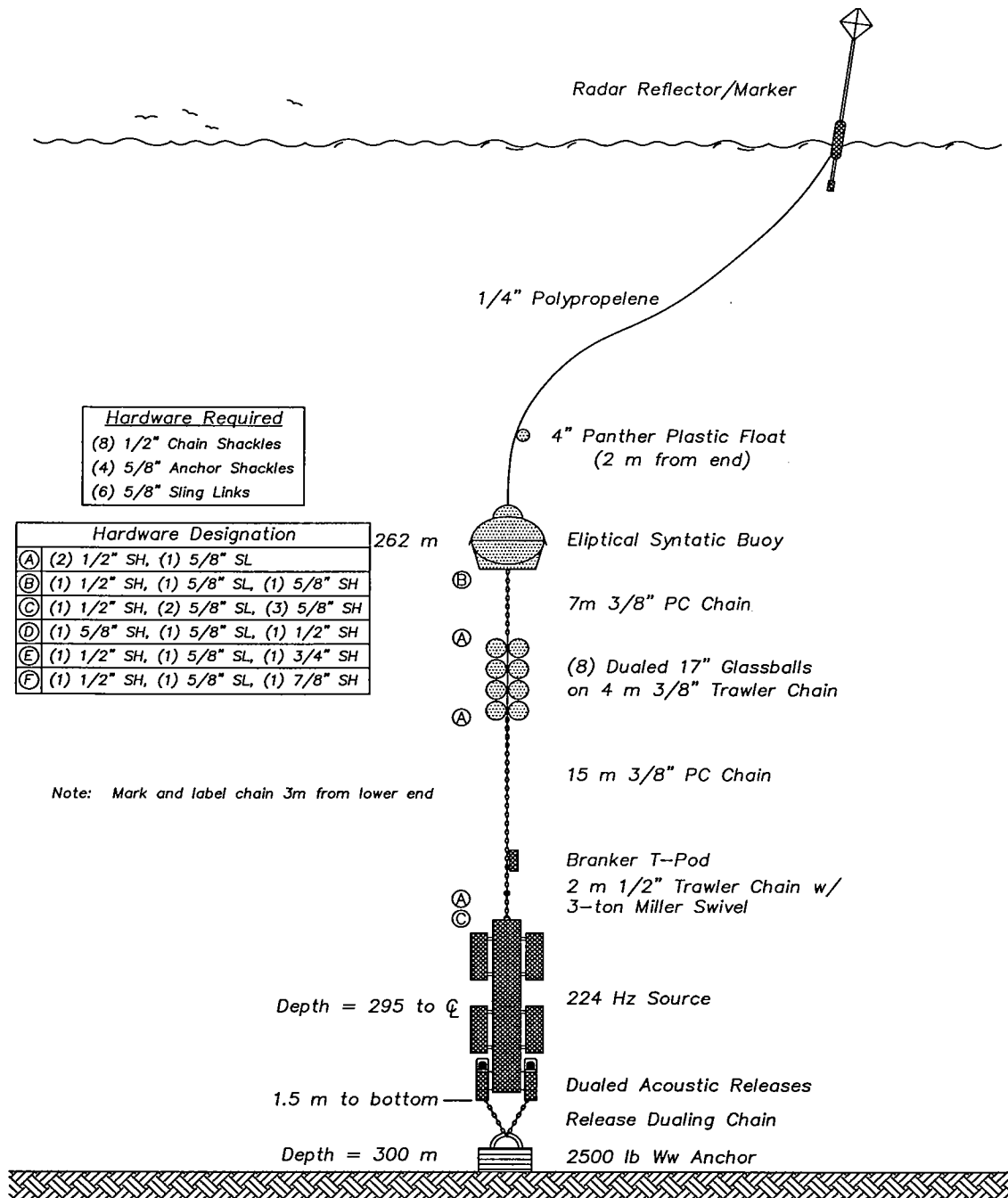
- Hardware Required**
- (14) 1/2" Chain Shackles
 - (2) 5/8" Anchor Shackle
 - (1) 7/8" Anchor Shackle
 - (7) 5/8" Sling Links
 - (1) 5/8" Master Link

| Hardware Designation | |
|----------------------|---------------------------------------|
| (A) | (2) 1/2" SH, (1) 5/8" SL |
| (B) | (1) 1/2" SH, (1) 5/8" SL |
| (C) | (1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH |
| (D) | (1) ML, (1) 1/2" SH |
| (E) | (1) 1/2" SH, (1) 5/8" SL, (1) 7/8" SH |

Belesy Doherty date: 07/09/96
 File: WINTERPRIMER rev: 01/15/97
 John Kemp Sheet 9 of 12

Winter Primer Experiment, NRL Thermistor Mooring (1 Required)

"K"



Hardware Required
 (8) 1/2" Chain Shackles
 (4) 5/8" Anchor Shackles
 (6) 5/8" Sling Links

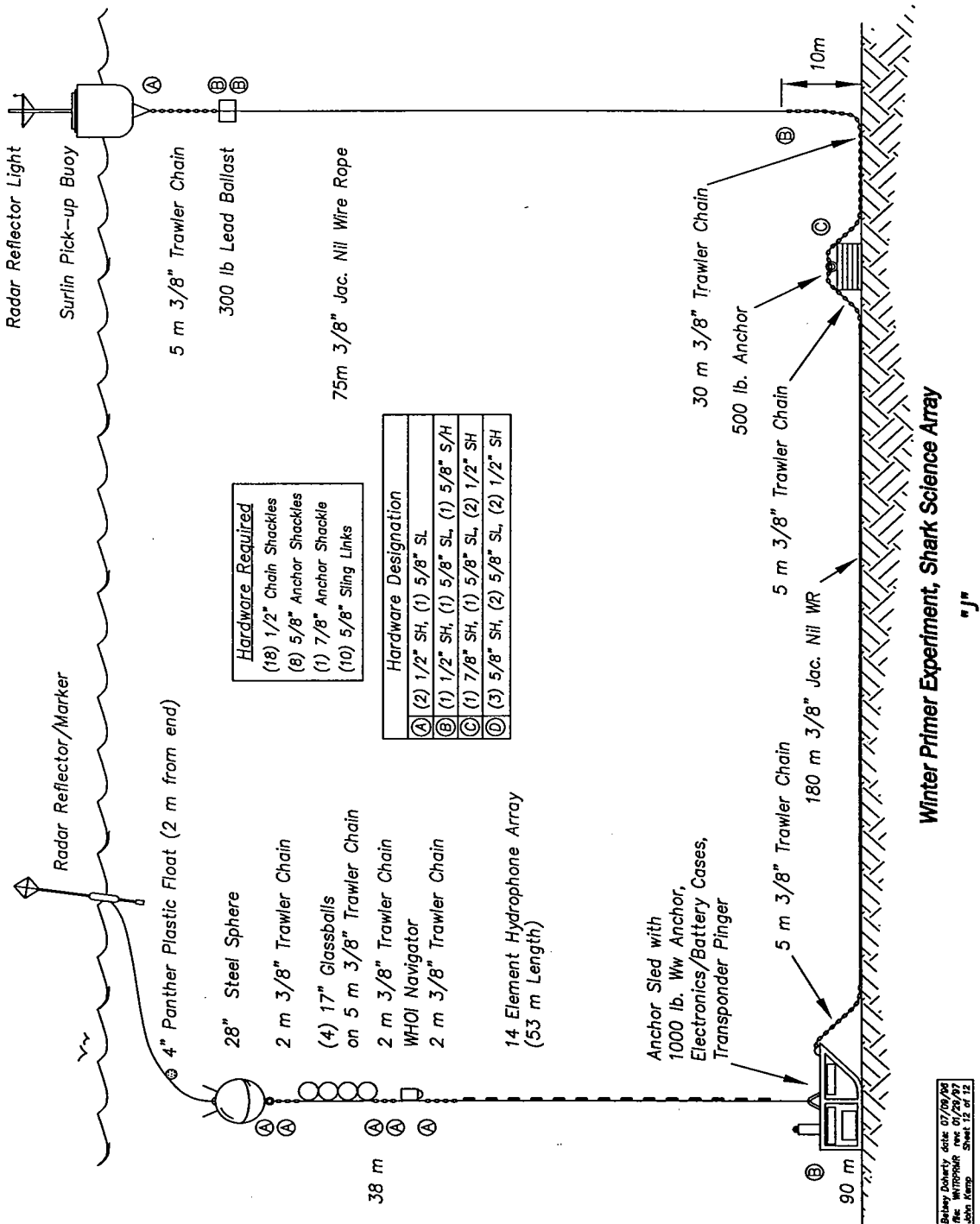
| Hardware Designation | |
|----------------------|---------------------------------------|
| (A) | (2) 1/2" SH, (1) 5/8" SL |
| (B) | (1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH |
| (C) | (1) 1/2" SH, (2) 5/8" SL, (3) 5/8" SH |
| (D) | (1) 5/8" SH, (1) 5/8" SL, (1) 1/2" SH |
| (E) | (1) 1/2" SH, (1) 5/8" SL, (1) 3/4" SH |
| (F) | (1) 1/2" SH, (1) 5/8" SL, (1) 7/8" SH |

Note: Mark and label chain 3m from lower end

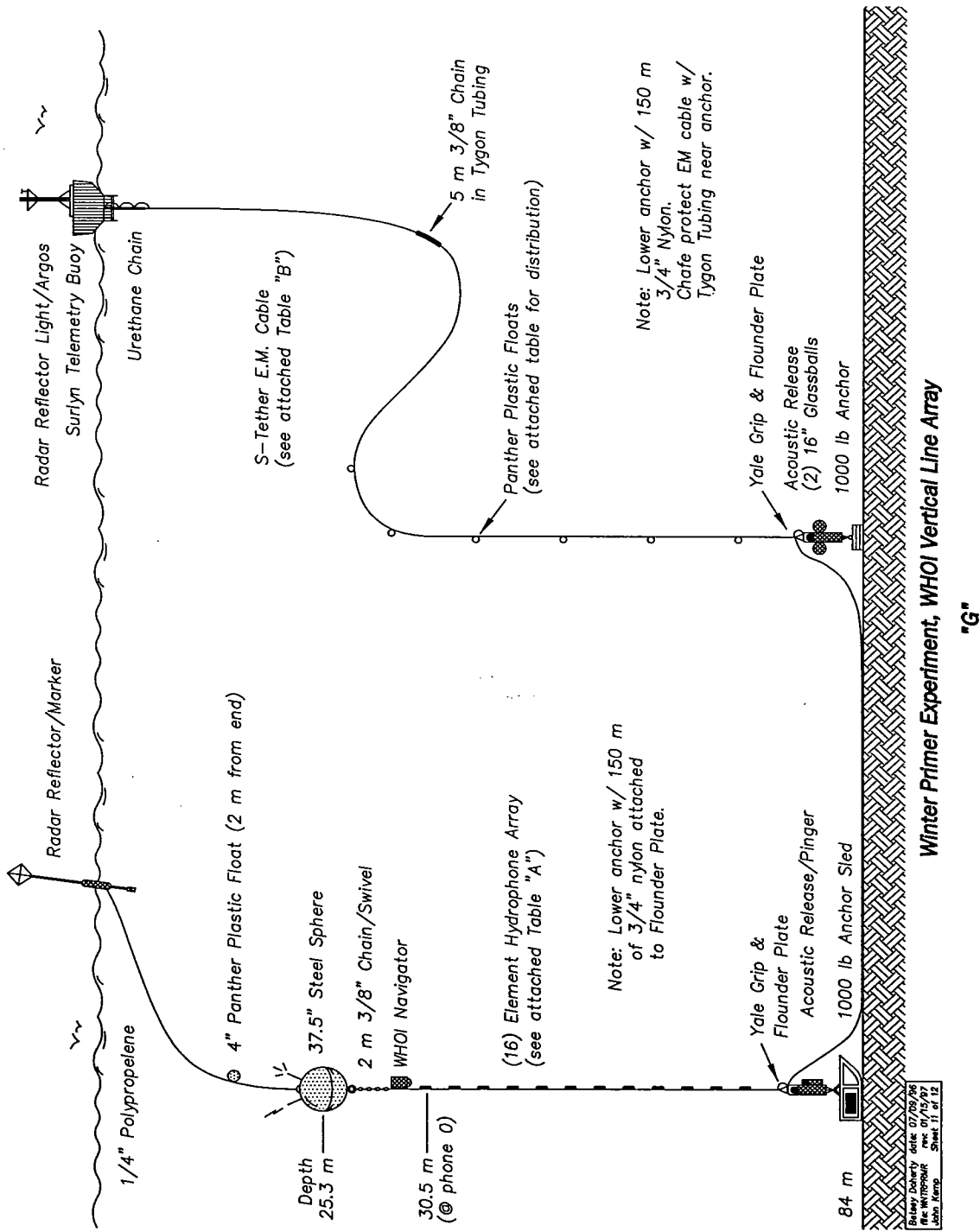
Winter Primer Experiment, 224Hz Tomo Source Mooring

Delaney Doherty date: 07/09/96
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 John Kemp Sheet 10 of 12

"A"



Revised: 01/07/04
 Date: 01/07/04
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| 16. Abstract (Limit: 200 words) A joint acoustics and physical oceanography experiment was conducted in the winter of 1997 on the shellbreak and continental slope south of New England in the Middle Atlantic Bight (figure 1). This experiment, Primer4, provided a seasonal contrast to the previous summer Primer3 experiment and had the same goals and tasks: to study the thermohaline variability and structure of the shelfbreak front and its effects on acoustic propagation. To accomplish the linked oceanographic and acoustic objectives of this experiment, a combination of measurements (fig 2) were made. Seasoar hydrography, shipboard ADCP measurements, Satellite IR sea surface temperature field observations, and AXBT drops were employed to study the larger scale oceanographic fields. To study the finer scale, which includes internal waves, a number of rapid-sampling thermistor strings and current meters, including a moored, upward looking ADCP, were deployed. The acoustics components consisted of three 400 Hz tomography transceivers, a 224 Hz source and two hydrophone arrays. To study the geoacoustic parameters in the bottom a number of SUS charges were also deployed. The field setup was approximately the same for both the summer 1996 and winter 1997 experiments; however the weather conditions and the thermal structure of the mixed layer were radically different. This report is dedicated to the data from the Winter 1997 Primer4 experiment. | | 14. | |
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