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14 NORDA-TECHNICAL NOTE 44 TN-44

LEVEL II

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# ENVIRONMENTAL VARIABILITY DURING THE CHURCH STROKE II CRUISE 5 EXERCISE.(U)

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10 PAUL J. BUCCA

9 Final rept. 9 Nov-16 Dec 77

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Ocean Acoustics Division

Naval Oceanographic Laboratory

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## EXECUTIVE SUMMARY (U)

(C) During the period 9 November through 16 December 1977, 160 XBTs and 127 AXBTs were deployed during Cruise 5 of the CHURCH STROKE II Exercise in the Philippine Sea. The environmental data collection effort was centered around the exercise baseline (12Ø-20ØN along 132ØE) and at various acoustic sites along this track. In addition, oceanographic data were collected along an acoustic projector tow located in the vicinity of the southern end of the Ryukyu Island arc. AXBT probes were deployed by the Oceanographic Development Squadron Eight (VXN-8) aircraft throughout these areas to coincide with acoustic events.

(U) OCEANOGRAPHIC FINDINGS

(U) Typhoon Lucy, a storm which packed sustained winds of 120 mph, had only a minimal effect on the sound speed structure along the baseline as late as 2-1/2 days after its passage. The lack of observed variability may have resulted from the mixing generated by the passage of three previous typhoons and one tropical storm in four months and the relaxation time prior to the post-storm data sampling.

(U) The most marked effect of the typhoon passage was in the persistency of the sonic layer after its passage as compared to the pre-storm analysis.

(U) Sound speed variation in the thermocline area exceeded 21.5 m/sec between Sites ES and EN owing to an upwelling center located south of the exercise baseline.

(U) ACOUSTIC IMPLICATIONS

(C) The absence of marked oceanographic variability resulting from the typhoon passage should reflect only a minimal effect on acoustic propagation.

(C) The passage of a major typhoon over a moored receiver provides an opportunity to study the differences between near field and distant ambient noise spectra.

(C) Depth excess is adequate for convergence zone propagation from a near-surface source from the LAMBDA array toward sites ES and EN located to the south and the north of the receiver, respectively. However, the extension of the Undaneta Ridge into the sound channel between the receiver and portions of the USS BEAUFORT projector tow to the northwest may preclude reliable acoustic path propagation.

## ACKNOWLEDGEMENTS (U)

(U) This work was sponsored by the Long Range Acoustic Propagation Project (LRAPP). The data collecting effort performed by personnel aboard the three exercise vessels and VXN-8 aircraft are greatly appreciated. Mr. W.C. Lippert of NORDA Code 341 was instrumental in the navigation rectification of all exercise platforms and the conversion of the temperature data to sound speed. Mr. Elwyn Graham of the DANALYT Corporation is thanked for his aid in supplying a statistically analyzed historical salinity data base tailored to the author's requirements.

# CONTENTS (U)

ILLUSTRATIONS (U)

TABLES (U)

## I. (C) INTRODUCTION

(C) The CHURCH STROKE II Cruise 5 exercise was conducted in the Philippine Sea during November and December 1977. Phase One took place from 9 to 23 November and Phase Two was executed from 23 November to 16 December. This report provides an analysis of Phase One environmental data only, since the data base collected during Phase Two (four expendable bathythermograph observations) is inadequate. This exercise was sponsored by the Chief of Naval Operations (OP-095) and was conducted under the direction of Commander-in-Chief, U.S. Pacific Fleet (CINCPACFLT). The program is under the general technical supervision of the Long Range Propagation Project (LRAPP) of the Naval Ocean Research and Development Activity (NORDA). NORDA Code 341 has been funded to analyze and report the non-acoustic data collected during the exercise. A detailed description of the exercise is given in the Exercise Plan for CHURCH STROKE Two, Cruise 5, Long Range Acoustic Propagation Project (1977).

## II. (C) DISCUSSION OF ENVIRONMENTAL DATA

### A. (U) DATA DISTRIBUTION

(U) The oceanographic environment in the exercise area was sampled primarily by the shipboard Expendable Bathythermograph (XBT) and the Airborne Expendable Bathythermograph (AXBT). Figure 1 shows the positions of 160 XBTs deployed by the three exercise vessels, and Figure 2 shows the locations of the 127 AXBTs deployed by the Oceanographic Development Squadron Eight (VXN-8) RP3A Orion aircraft.

(C) Figure 3 depicts the operational portions of the tracks occupied by the exercise vessels superimposed on the surface current regime. M/V SEISMIC EXPLORER towed the LAMBDA acoustic array and focused its data collection effort in the vicinity of Site E. The M/V INDIAN SEAL deployed XBT probes along the exercise baseline (130°E from 12°-20°N), and was responsible for towing an HX-373 projector and implanting various acoustic and meteorological systems. The environmental data were collected by USS BEAUFORT during an HX-231F projector tow along various tracks that were either radial or broadside to LAMBDA at site E (those track segments labeled "HX"). The VXN-8 aircraft deployed AXBT probes during six sorties at various locations and at times which were coincidental with acoustic measurements. In areas of AXBT deployment, the VXN-8 aircraft collected sea surface temperature data measured via an Airborne Radiation Thermometer (ART) to determine the areal extent of any oceanographic fronts which might have existed in the exercise area. In addition, laser wave height profilometer data and sea surface photographs were taken along large portions of each track to determine the effect of wind-generated ambient noise during the exercise. The wave height and photographic data are not reported in this document. Illustrations and tables of the exercise vessels' rectified navigation are located in Appendix A.

### B. (U) DATA TREATMENT AND RELATIVE DATA ACCURACY

(U) The XBT and AXBT data were recorded as analog records. These records were visually quality checked and digitized on magnetic tape using an ALTEK Model AC-90 digitizer. The data set, which contains temperature vs. depth pairs, was visually checked to guarantee the quality of the digitized output.

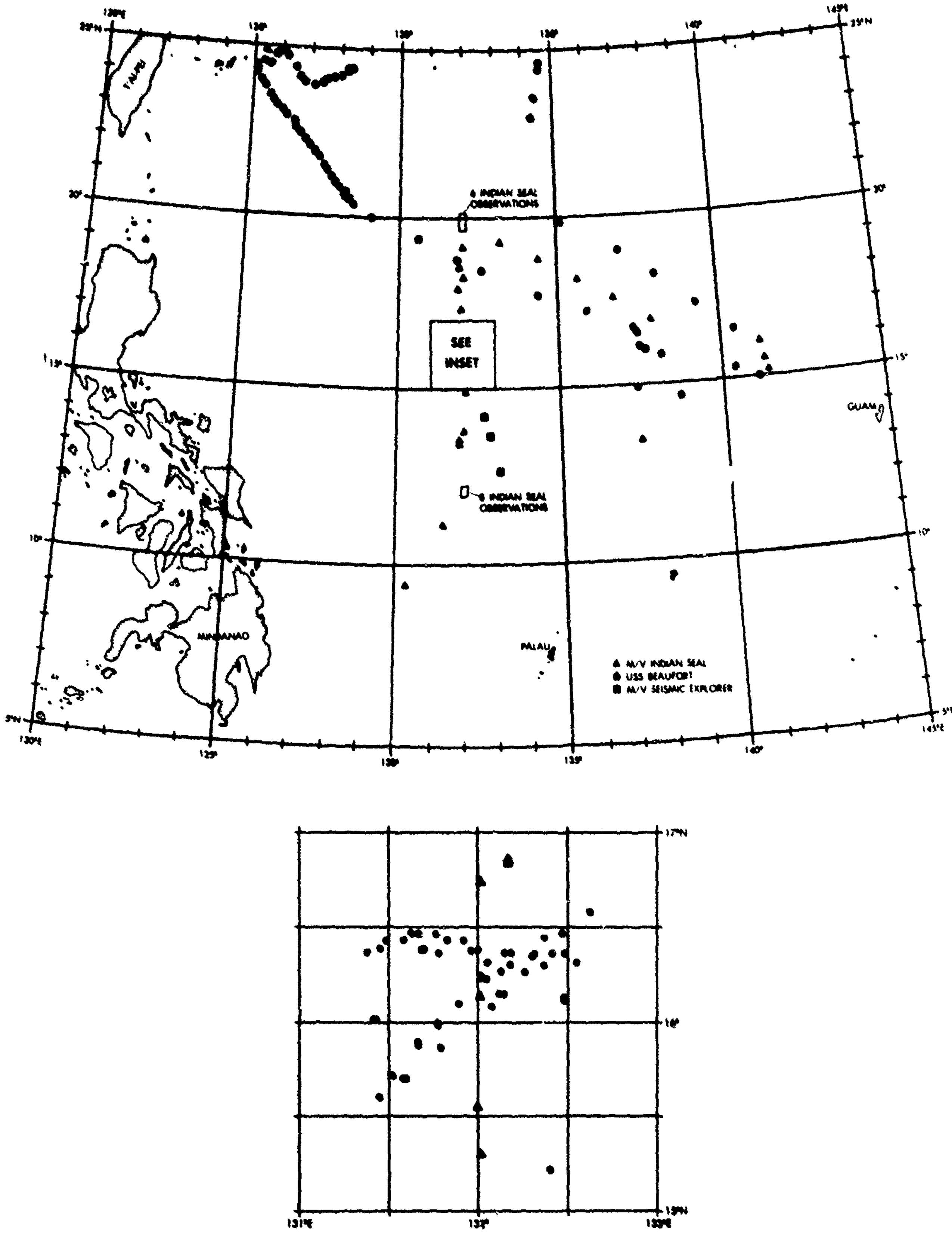


Figure 1 (C). Location of XBT data taken by exercise vessels (U)

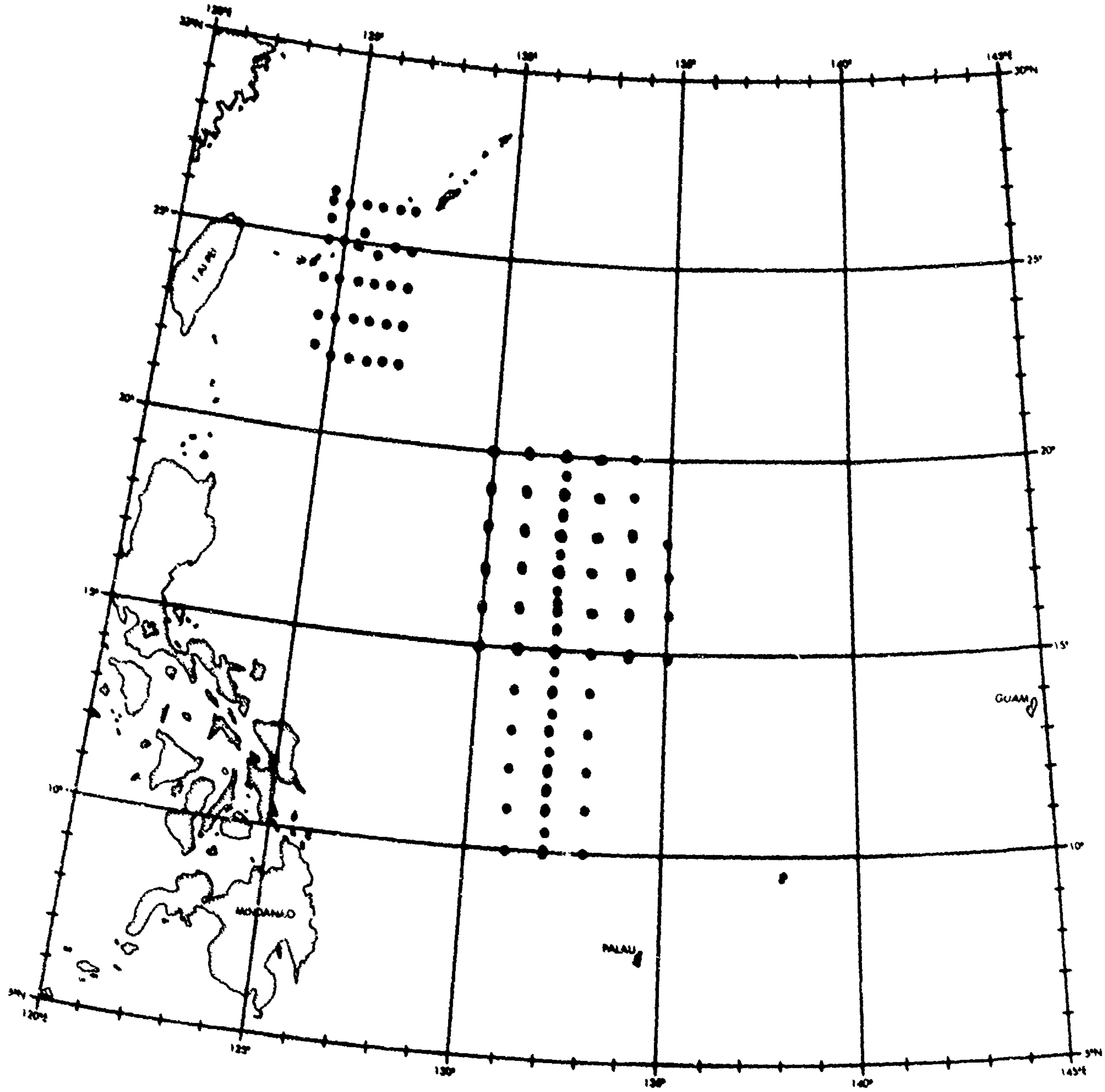


Figure 2 (C). Location of AXBT data taken by VXN-8 aircraft (U)

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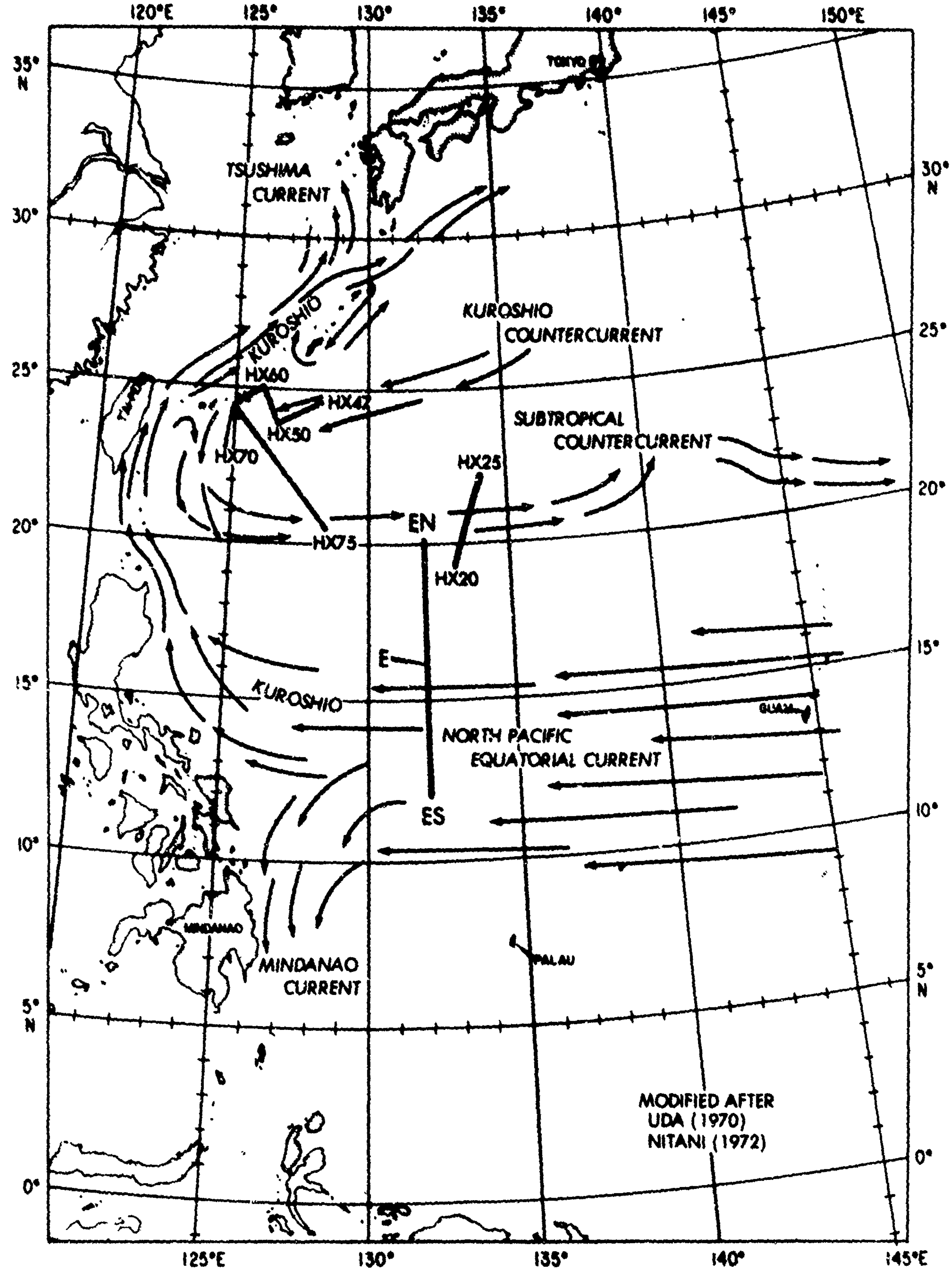


Figure 3 (C). Generalized circulation in the exercise area (U)

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(U) Historical salinity values, used to convert the temperature-depth data to sound speed, were obtained from the LRAPP data bank. Composites of salinity profiles were plotted in ten unique oceanographic regimes and compared to the numerical mean profile. The salinity profile that most closely resembled the mean was used as the model to convert all temperature data in that regime to sound speed. All sound speed values were calculated from the equation of Wilson (1960).

(U) The XBT probe has an accuracy of about $\pm$ 0.2°C, which results in a calculated sound speed accuracy of about $\pm$ 0.7 m/sec (1.4 m/sec extreme spread), assuming that approximate salinities are chosen. Additional error is introduced which results from inaccuracies in Wilson's equation; however, the primary source of error is attributed to the temperature resolution accuracy of the XBT probe. The extreme variation in sound speed of all probes that extended to 2000 m was 1.7 m/sec. The 0.3 m/sec variation between the extreme spread of the instrument and that observed can be accounted for by environmental variation. An average sound speed of 1491.5 m/sec at 2000 m depth as calculated from the XBT data agrees well with the historical average (1491.2 m/sec) as derived from hydrocast data.

## III. (U) OCEANOGRAPHIC SETTING

(U) The surface currents, as depicted in Figure 3, indicate that the exercise area in the vicinity of Site E south to Site ES is occupied by the North Pacific Equatorial Current. The Kuroshio Current, whose source waters emanate from the North Pacific Equatorial Current, flows to the west of the Ryukyu Island arc and exerts only a minimal effect in the exercise area. Uda (1969) indicates that the eastward—flowing Subtropical Countercurrent lies between 20° and 24°N in the exercise area and extends to a depth of approximately 300 m. The Subtropical Convergence, as described by Uda (1955), lies to the north of and is parallel to the Subtropical Countercurrent, and separates the Subtropical Mode Water to the north from the tropical waters to the south. Subtropical Mode Water is characterized by an isothermal layer and water of approximately 18°C that is present between 150 and 300 m depth, and is capable of producing secondary sound channel structures. The Kuroshio Countercurrent contains Kuroshio Water as it exists south of Japan and represents the only relatively cool water in the exercise area.

## IV. (U) METEOROLOGICAL VARIABILITY DURING THE EXERCISE

(U) Meteorological conditions played a very large role during the exercise. The entry of Typhoon Lucy into the exercise area between Guam and Palau caused a suspension of the exercise from 1 to 7 December. Figures 4 and 5 show the positions and wind speeds associated with Lucy every 12 hours (except for 060000Z) while it was located in the exercise area.

(U) Lucy entered the Philippine Sea classified as a tropical storm (maximum sustained winds of at least 34 kn) and was upgraded to a typhoon (maximum sustained winds of at least 64 kn) at 030000Z December, very soon after the eye passed the vicinity of Site ES. Maximum wind speeds were obtained (120 kn sustained winds with gusts to 145 kn) at 040000Z December just prior to its northward excursion. After proceeding to the north, then in an easterly direction,

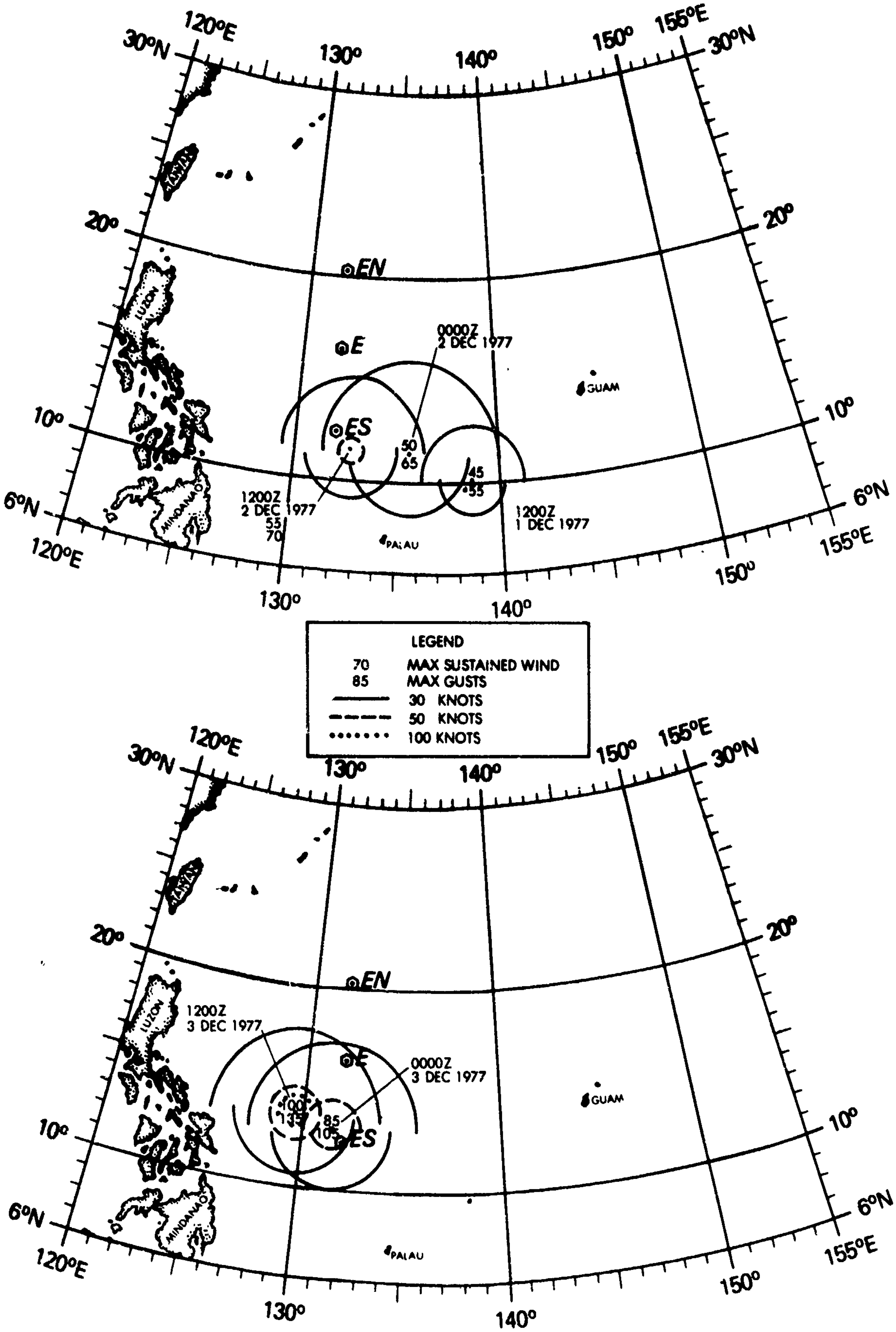


Figure 4 (C). Wind speeds in exercise area (011200Z Dec — 031200Z Dec 1977)(U)

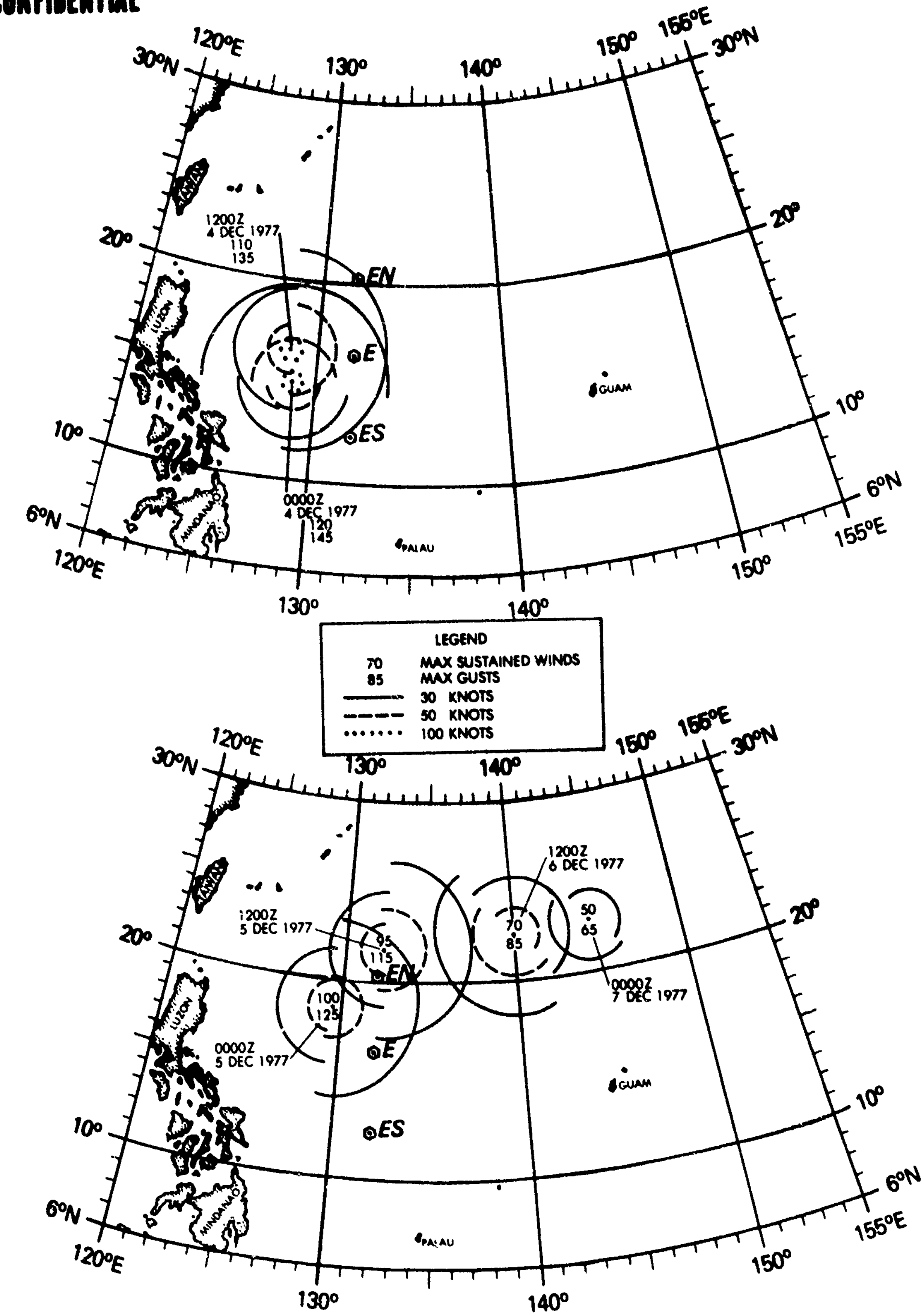


Figure 5 (C). Wind speeds in exercise area (040000Z Dec — 070000Z Dec 1977) (U)

cold air entrainment and the presence of the upper atmospheric jet stream caused, respectively, a weakening (subsequent downgrading to tropical storm at 061800Z December) and an acceleration of the storm center. Figure 6 presents an areal contour chart of wind speeds as they affected the exercise area during Lucy's tenure in the Philippine Sea. Caution must be used in interpreting this illustration, since it is constructed from the radii circles (as obtained from reconnaissance flights) on the two previous figures and not from actual measurement grids. Nevertheless, it presents a coarse depiction of the areas that were most affected by Typhoon Lucy; i.e., those directions from which wind-generated ambient noise values would potentially be the greatest with respect to the moored receivers. The passage of a storm of this magnitude proximate to the ACODACS should offer an excellent opportunity to study the characteristics of both locally generated and distant sources of ambient noise.

## V. (U) SOUND SPEED VARIABILITY ALONG THE EXERCISE BASELINE

(C) Oceanographic variability along the baseline was measured at the beginning of the exercise (pre-storm) and toward the end of the exercise (post-storm) by both ship and aircraft. Figure 7 shows a contoured sound speed section and composite of selected profiles along the 132°E baseline from Site EN (beginning 270600Z November) to Site ES (ending 301801Z November) that were collected by M/V INDIAN SEAL. The first effects of then Tropical Storm Lucy were experienced at Site ES between 011200Z December and 020000Z December. Figure 8 presents a similar sound speed section and composite along the baseline taken by VXN-8 on 8 December, six days after Lucy passed over Site ES, and two and one-half days after it achieved its closest point of approach to Site EN. Figure 9 presents a comparison of selected sound speed contours, sonic layer and critical depth positions extracted from Figures 7 and 8.

(C) Comparisons of these sections indicate that variability of the oceanographic environment resulting from the passage of Typhoon Lucy at the times of these measurements was minimal. The upper 400 m of the sea surface north of approximately 17°30'N appeared to have been altered more than the baseline to the south of 17° 30'N. This can be explained by the relatively short time between the storm's passage and when the measurements were made (relaxation time), and its stronger intensity at Site EN as compared to that at ES. North of 17°30'N, for instance, the sonic layer depth prior to the typhoon averaged 62 m; after the storm, the sonic layer had deepened to 75 m, while there was no perceptible change in this parameter south of 17°30'N. The sonic layer along the entire baseline became much more uniform after the passage of the typhoon as compared to its existence prior to the storm. However, the most apparent aspect of the near-surface structure is the relatively deep layer depth which existed prior to Lucy. It is probable that a layer of this magnitude might have been created by three previous typhoons and one tropical storm which had traversed this area in the preceding four months. The occurrence of these prior disturbances could have created sufficient mixing of the upper water column so as to minimize the effects that Lucy might have exerted. Since the oceanographic environment was not markedly affected, the effects of the storm on sound propagation should have been minimal.

(C) Sound speed values below the sonic layer were affected by only small displacements of isolines. Figure 9 shows that the 1520 m/sec isoline was found to be shallower in the water column (due to cooler temperatures) after the storm passage, especially north of 17°30'N where relaxation times were shorter and the storm was more intense. Variations in critical depth (in this instance, a

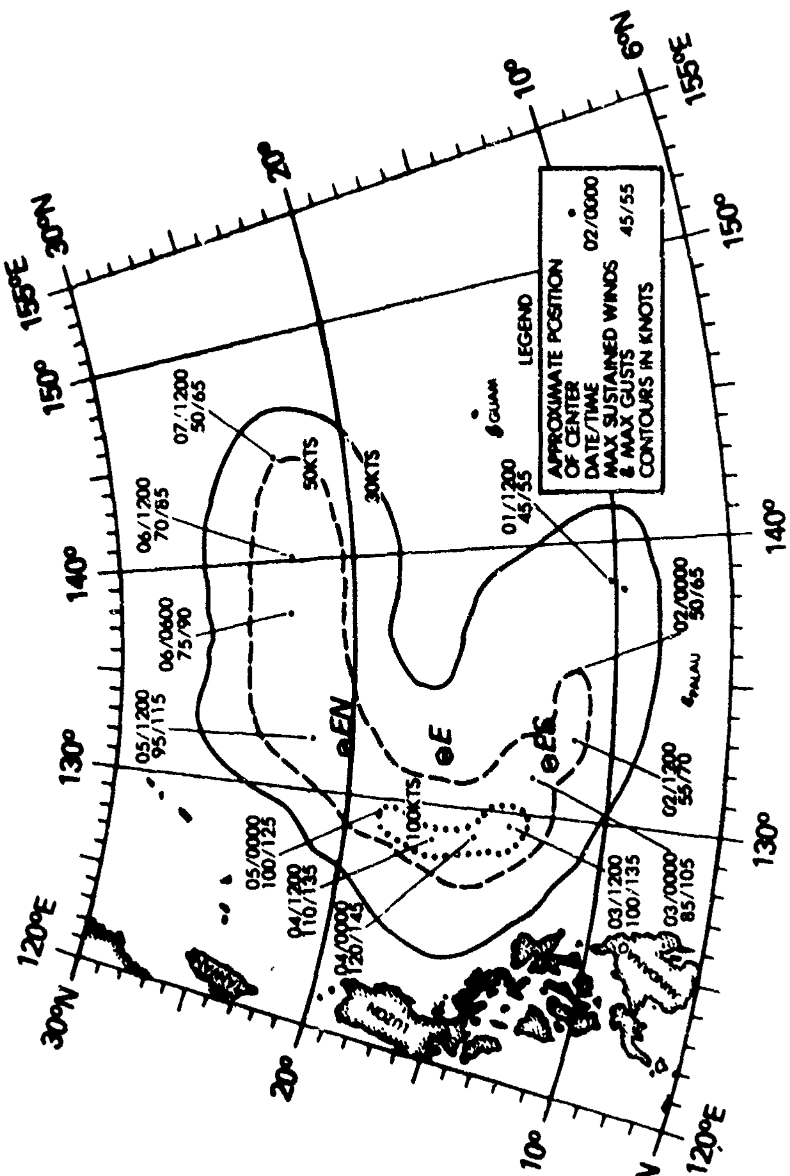


Figure 6 (C). Areal contours of wind speed during the storm's tenure in the exercise area (U)

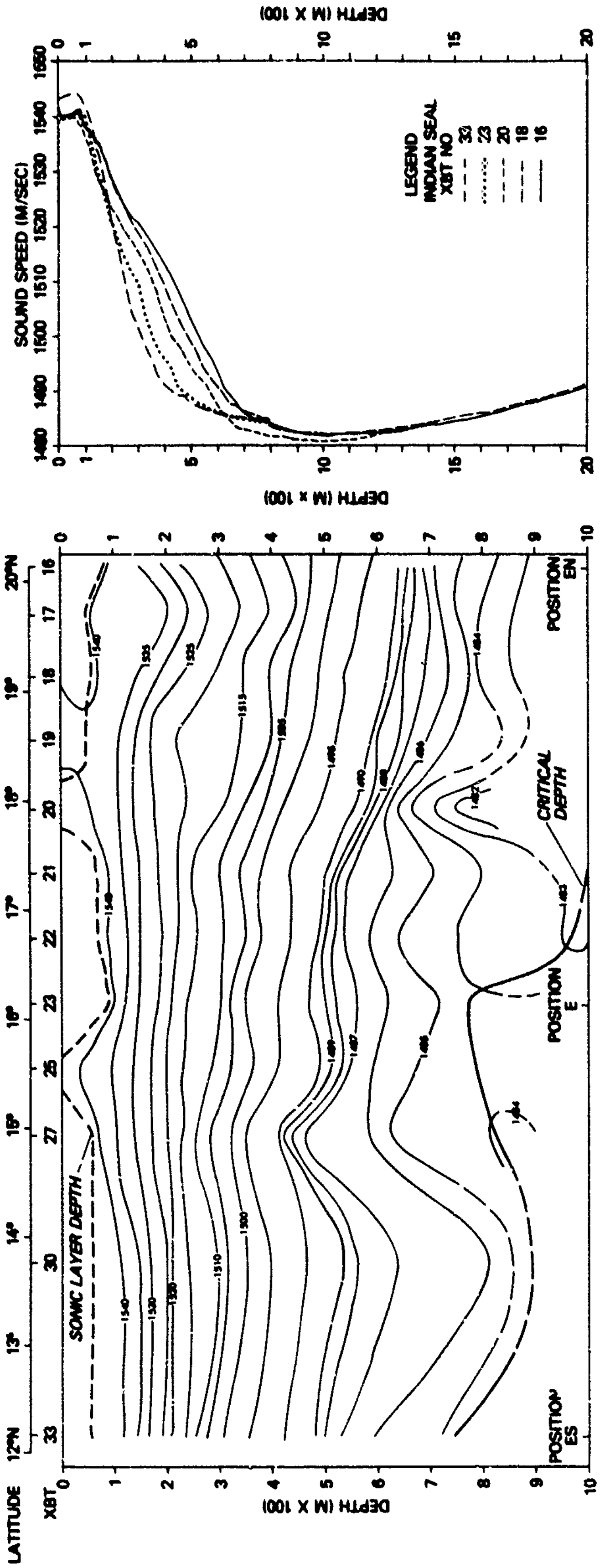


Figure 7 (C) Contoured section and composite of sound speed variability along the exercise baseline prior to Typhoon Lucy (U)

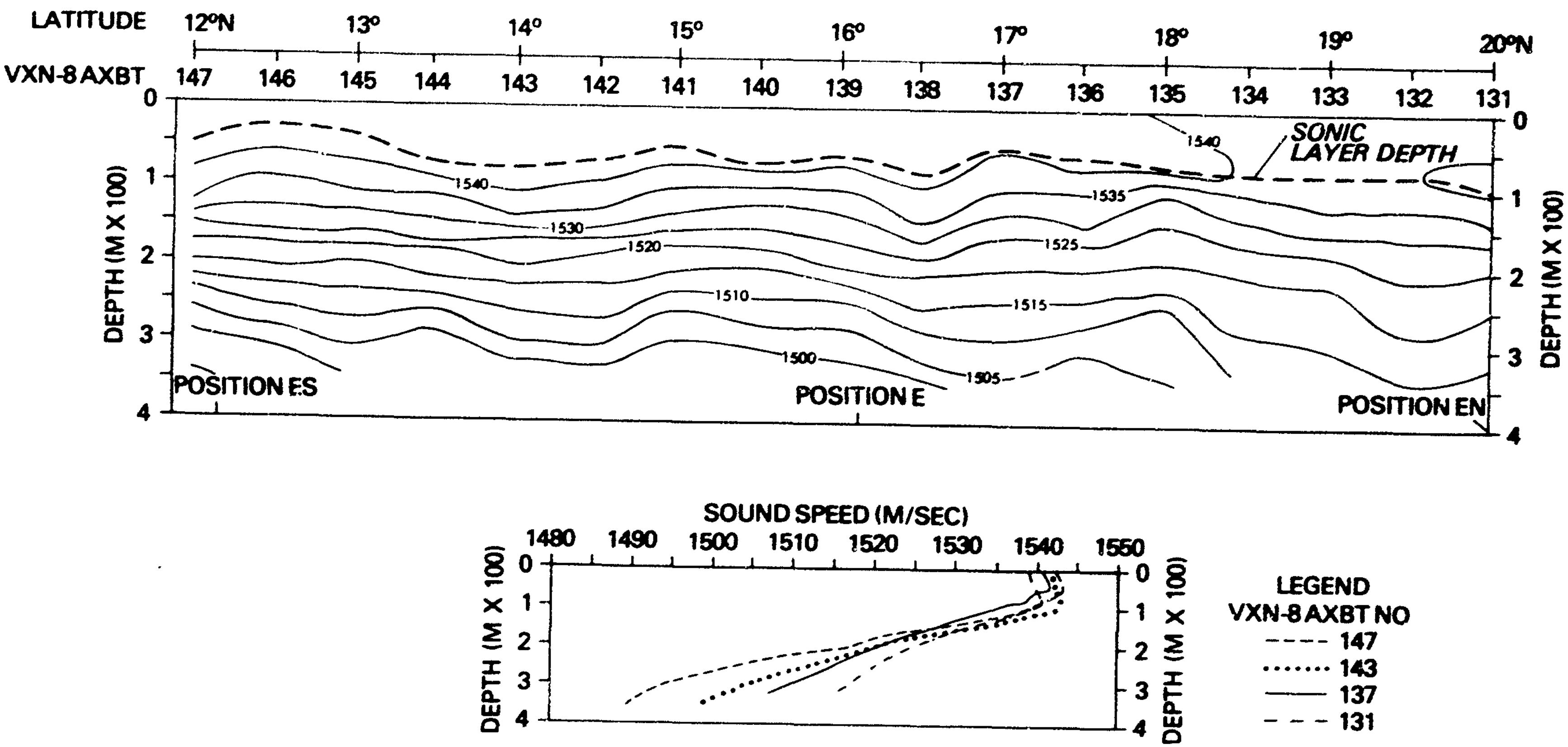


Figure 8 (C). Contoured section and composition of sound speed variability along the exercise baseline after the passage of Typhoon Lucy (U)

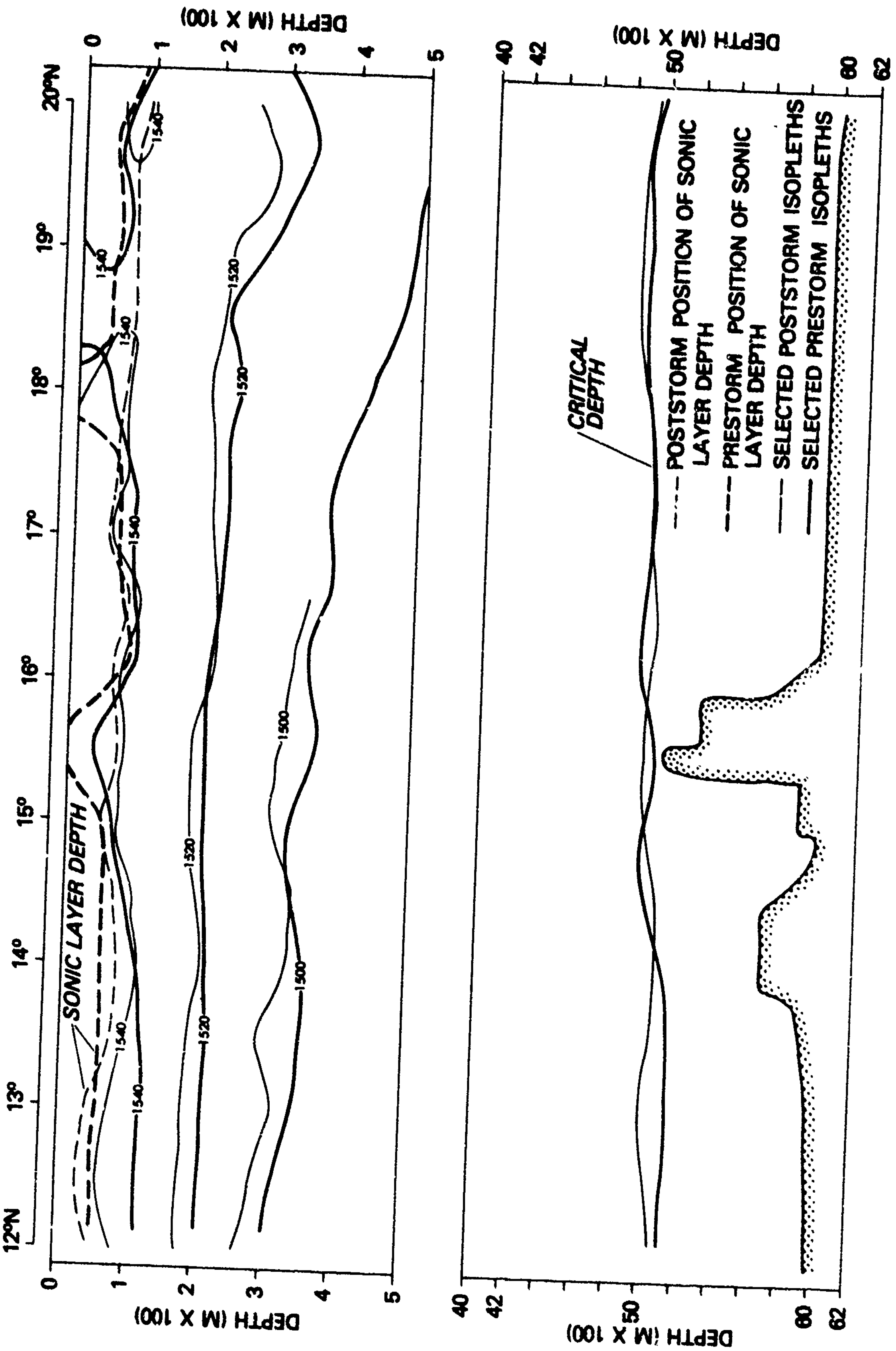


Figure 9 (C). Comparison of selected sound speed contours and parameters before and after the passage of Typhoon Lucy (U)

reflection of the sound speed at the sonic layer depth) as a result of the typhoon are almost nonexistent. From Site E to the north of Site EN, there is a large region where the critical depth is shoaler than the bottom topography (i.e., regions of depth excess). In this area, depth excess is adequate for convergence zone propagation from a near- surface source. In the immediate vicinity of Site E, however, the Central Basin Ridge very nearly coincides with the bottom of the sound channel.

(U) The large spatial variability not related to the typhoon is evident on both baseline sections. Sound speed values at 400 m depth on the composite of Figure 7 differ by 21.8 m/sec between Sites ES and EN. Variation at this depth is also evident by the deepening of the sound speed isolines from Site ES to Site EN. Nitani (1970) documents the existence of a cold eddy associated with upwelling of deep water in the vicinity of 7°N. It is likely that the relatively cool water found along the southern portion of the baseline is a result of this upwelled water. This phenomena results in a pronounced thermocline, hence, a stronger negative sound speed gradient below the surface mixed layer.

(U) The depth of the deep sound channel axis is also affected by the upwelling center to the south of Site ES. The sound channel axial depth, which averages 783 m from Site ES to 16°15'N along the baseline, increases to an average value of 1019 m between 16°45'N and Site EN. This deepening of the axial depth to the north is a result of weaker sound speed gradients (caused by warmer temperatures) above the sound channel.

## VI. (U) SOUND SPEED VARIABILITY AT EXERCISE ACOUSTIC SITES

(U) Typical sound speed profiles at Site ES both before and after the typhoon are illustrated on Figure 10. These profiles were chosen from seven pre-storm measurements and two post-storm measurements taken by M/V INDIAN SEAL and VXN-8 aircraft within 11 nm of Site ES. The slightly lower sound speed in the upper water column, present in the post-storm profile, can be a result of either of the typhoon or of oceanographic variability independent of meteorological conditions.

(U) Figures 11 and 12 show sound speed composites and typical profiles collected at Site E before and after the typhoon, respectively. Each composite was compiled from an analysis of 18 observations taken during the LAMBDA operational periods. Since the pre-storm composite contains data taken within a 30 nm radius and the post-storm composite was taken within a 42 nm radius (both over a five- day period), temporal as well as spatial change is probably responsible for the observed variability. Nevertheless, the variability observed at Site E over the duration of the exercise is acoustically negligible.

(U) The typical sound speed profiles, as shown in Figure 13, resulted from five exercise measurements available within 17 nm of Site EN prior to and after the storm. The deeper mixed layer and lower sound speed values in the mixed layer can be attributed to the effects of Typhoon Lucy, since the relaxation time was only three days after its passage.

## VII. (U) SOUND SPEED VARIABILITY ALONG THE USS BEAUFORT TRACK

(U) The CW projector tow made by USS BEAUFORT between Sites HX-47 and HX-75 extended over areas of both depth excess and bottom limited regions of the

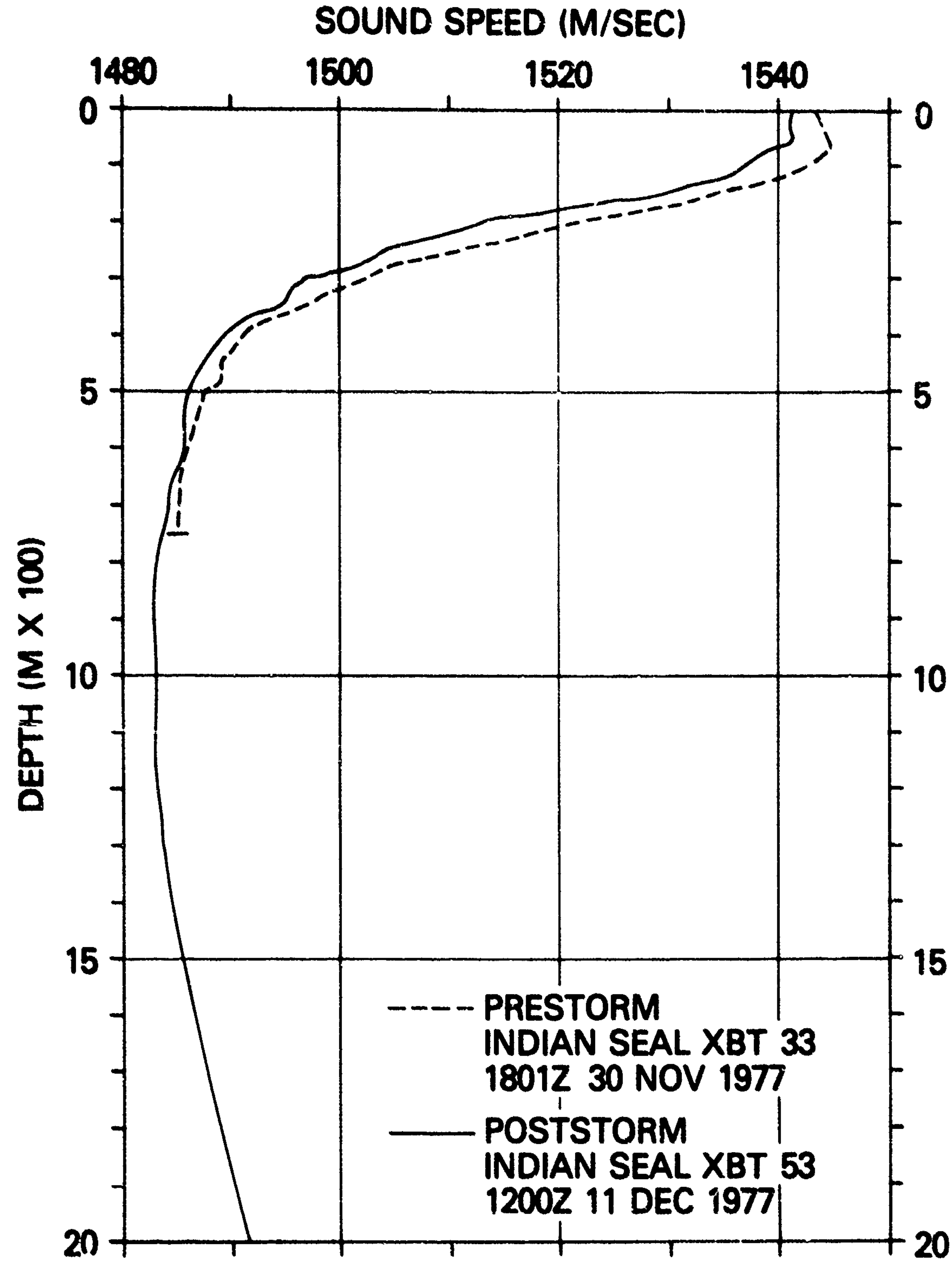


Figure 10 (C). Pre-storm and post-storm composite of sound speed variability of Site ES (U)

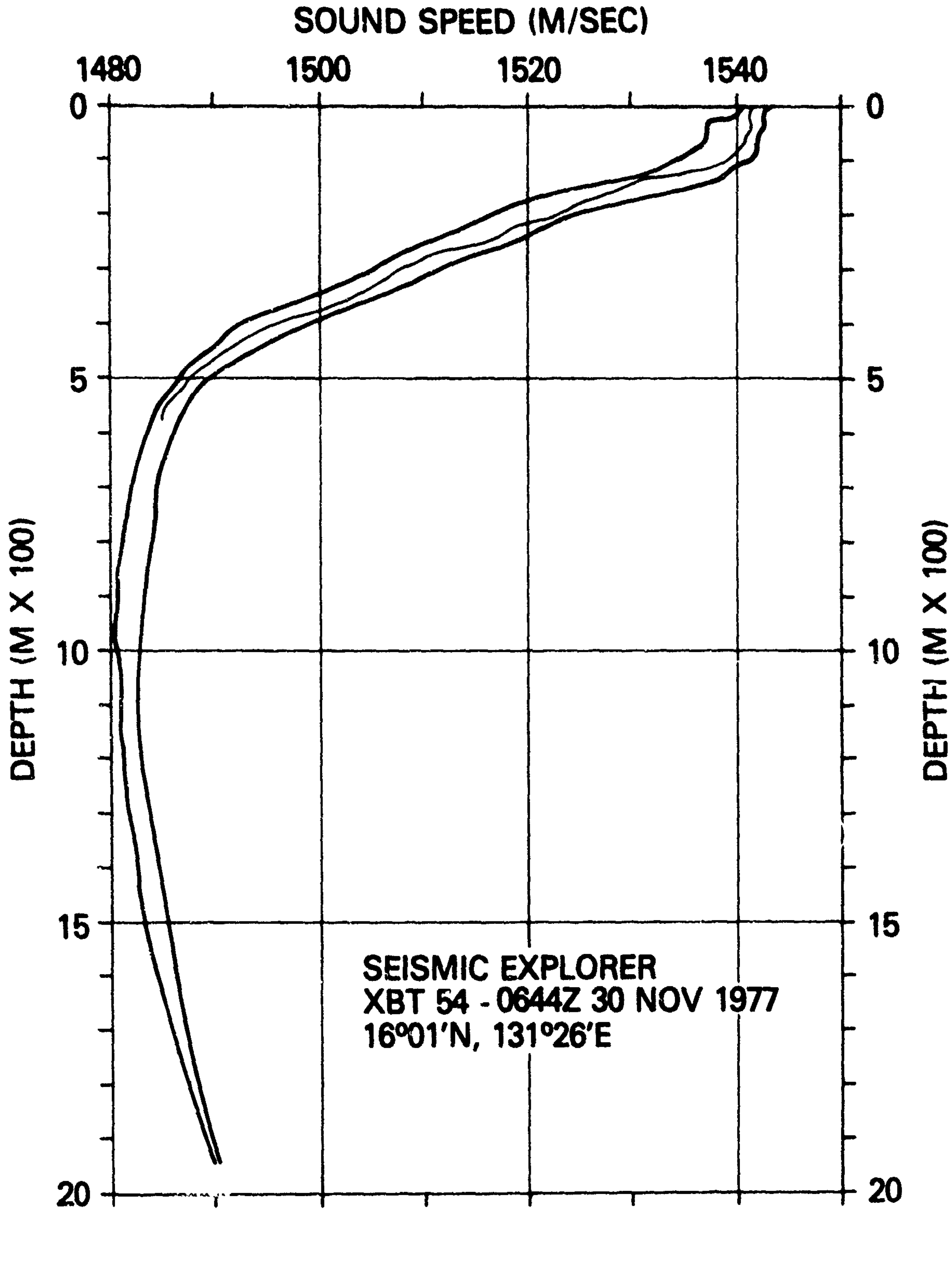


Figure 11 (C). Sound speed composite and typical profile during pre-storm LAMBDA deployment at Site E (U)

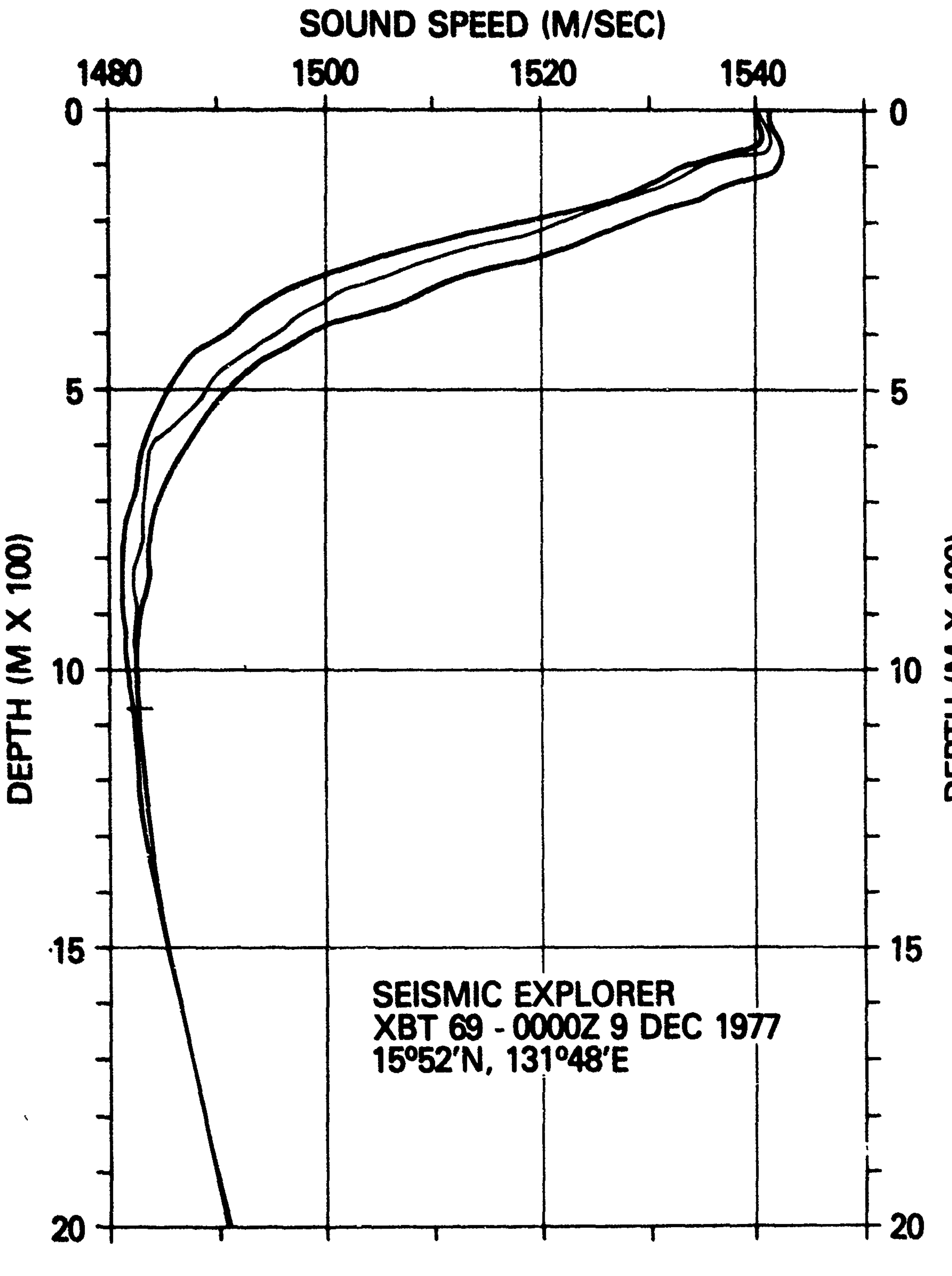


Figure 12 (C). Sound speed composite and typical profile during post-storm LAMBDA deployment at Site E (U)

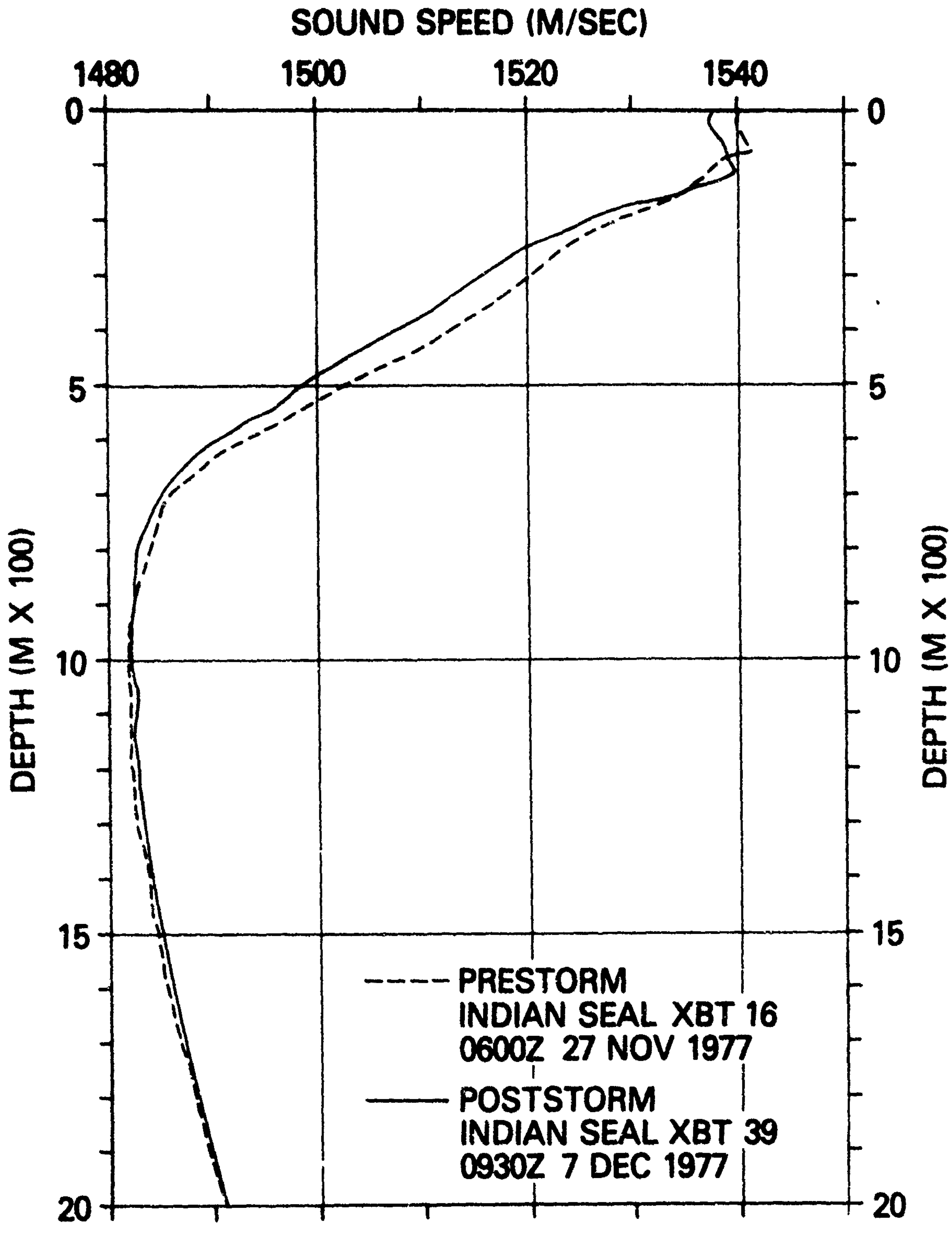


Figure 13 (C). Pre-storm and post-storm composite of sound speed variability at Site EN (U)

continental shelf. Figure 14 presents a sound speed section and Figure 15 illustrates a composite of five selected sound speed profiles along this track. The lack of near-surface sound speed variation and the persistent character of the sonic layer along the entire track are worthy of note. The retarded negative sound speed gradient between 200 and 400 m depth in the vicinity of Site HX-47 is caused by the existence of Subtropical Mode Water. This water mass, found to the north of the Subtropical Convergence, causes a pronounced bichannel sound speed structure north of the exercise area. The deep sound channel axis, discontinuous over the continental shelf, demonstrated little variation and remained generally deeper than 1000 m along the entire track. Critical depth also remained stable along the transit and exhibited little variation from its approximate 4600 m depth. The Ryukyu Trench offers depth excess as large as 2200 m, while the continental shelf associated with the Ryukyu Island arc and the Undaneta Ridge are bottom-limited.

(U) A VXN-8 AXBT and ART survey was taken over this area one and one-half days prior to the beginning of the USS BEAUFORT projector tow. A composite of all data from that survey revealed no evidence of surface or subsurface eddies which may have been generated by the Kuroshio Current and thus affected the environment east of the Ryukyu Island arc.

## VIII. (U) CONCLUSIONS

(C) The intrusion of Typhoon Lucy through the exercise area during 1-7 December interrupted the timing of the exercise events more seriously than it affected the environment. Sound speed sections taken along the exercise baseline (12°-20°N along 132°E) prior to and following the typhoon indicate that the northern portion of the baseline (north of 17°30'N) was more adversely affected than the southern portions. This observation, however, is not surprising, since the time between the storm's passage and that of the measurements was only two and one-half days at the northern end, while six days had elapsed since the storm had traversed the southern extremes of the baseline. The depth of the sonic layer, already deep from four tropical cyclones in as many months, increased only an average of 13 m north of 17°30'N and remained essentially unchanged south of this latitude along the baseline. Sound speed values below the mixed layer and critical depth changed very little as a result of the storm's passage. Consequently, the effect of the typhoon on sound propagation should have been minimal.

(U) Environmental variability as measured at acoustic Sites ES, E, and EN over the duration of the exercise was found to be acoustically negligible. Spatial variability along the baseline (that variability not related to the typhoon) was significant. The sound speed value at 400 m at Site ES, for instance, was 21.8 m/sec lower than at Site EN. This comparatively large variation in sound speed was largely confined to the thermocline area of the water column and was caused by a center of upwelling centered at 7°N below the southern limit of the baseline. The existence of this permanent feature is also reflected in a shoaling of the sound channel axis from an average of 783 m south of 16°15'N to 1019 m north of 16°45'N along the baseline.

(U) The most pronounced change in the sound speed structure along the track of the USS BEAUFORT lies in the transition from the isovelocity structure found below the mixed layer in the vicinity of HX-47 to the typical negative gradient found along the remainder of the transit track. The sonic layer depth deep sound channel axial depth and critical depth were very stable along the entire CW tow track.

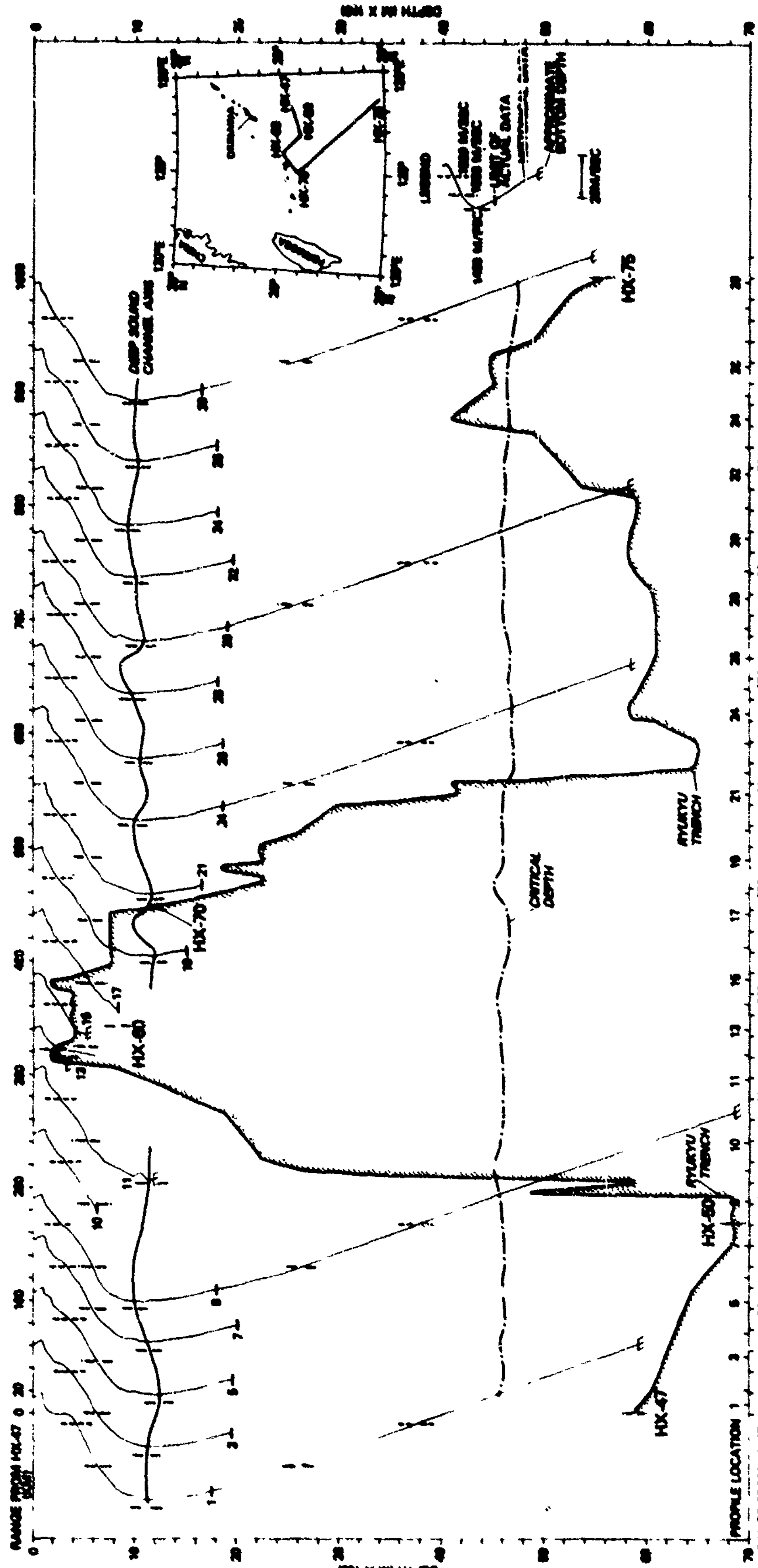


Figure 14 (C). Sound speed variability along USS BEAUFORT projector tow track, HX47 — HX75 (U)

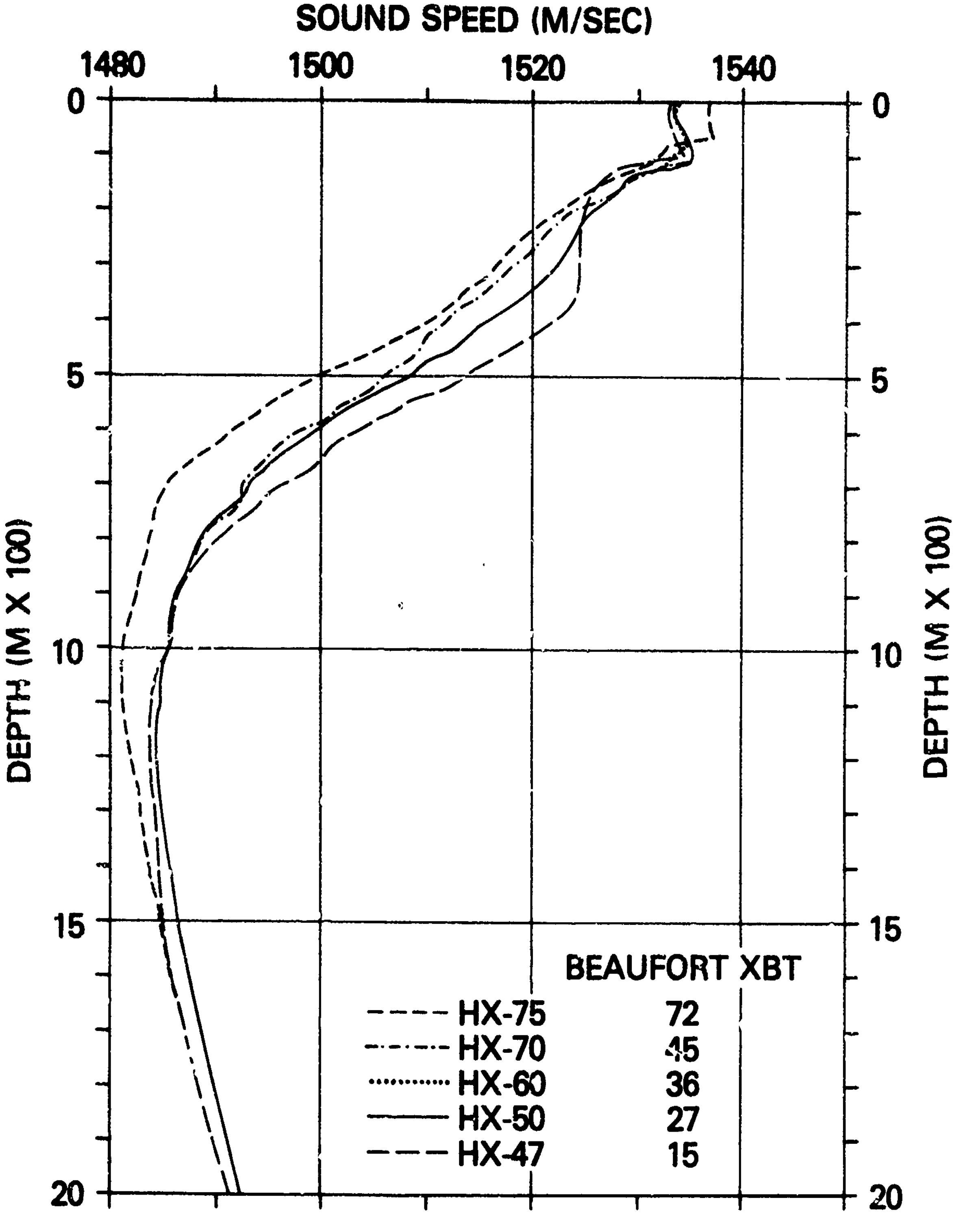


Figure 15 (C). Composite of selected sound speed profiles along the USS BEAUFORT tow track, HX47 — HX75 (U)

## IX. (U) REFERENCES


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# APPENDIX A (U)

## RECTIFIED NAVIGATION OF EXERCISE SURFACE PLATFORMS (U)

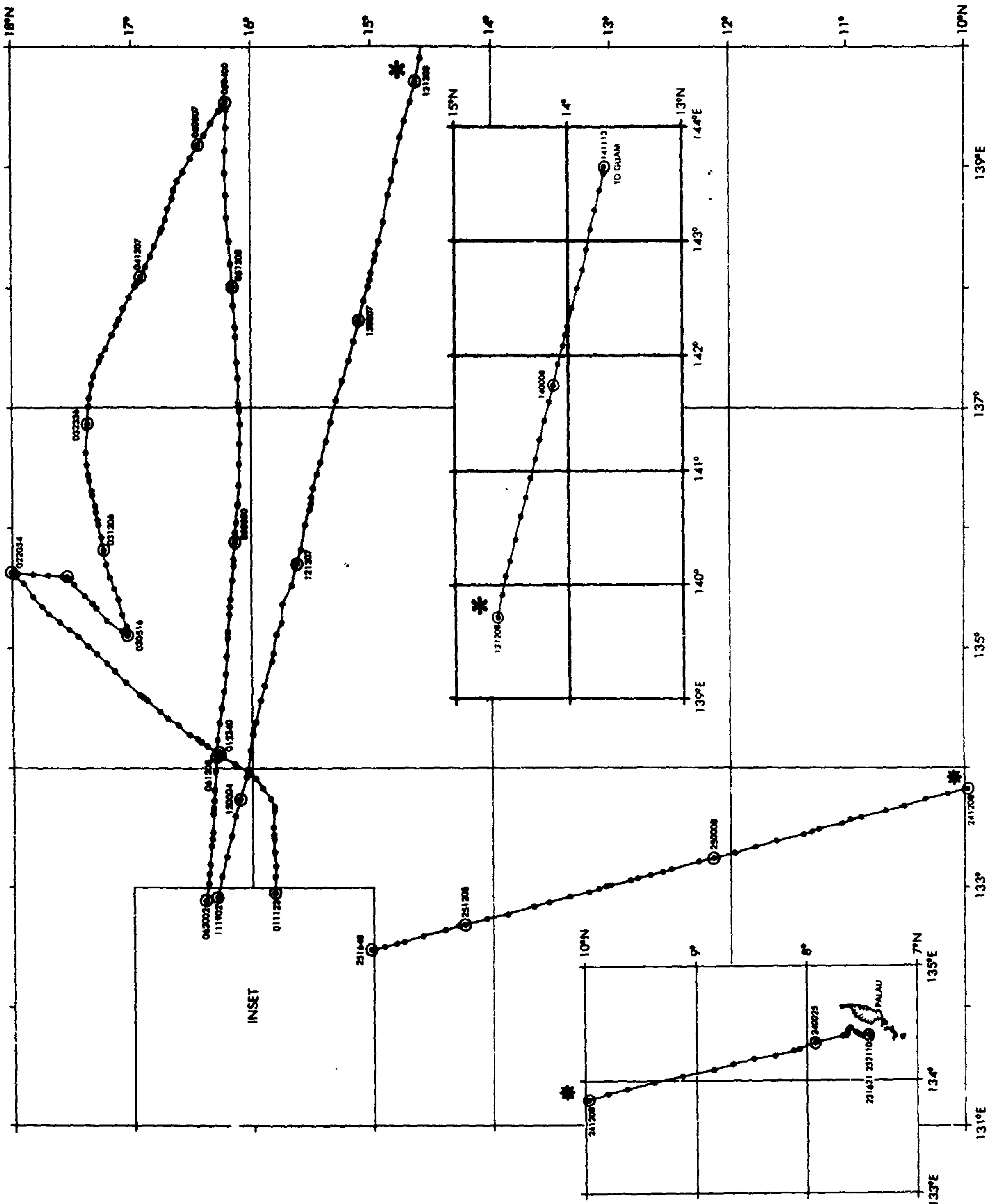
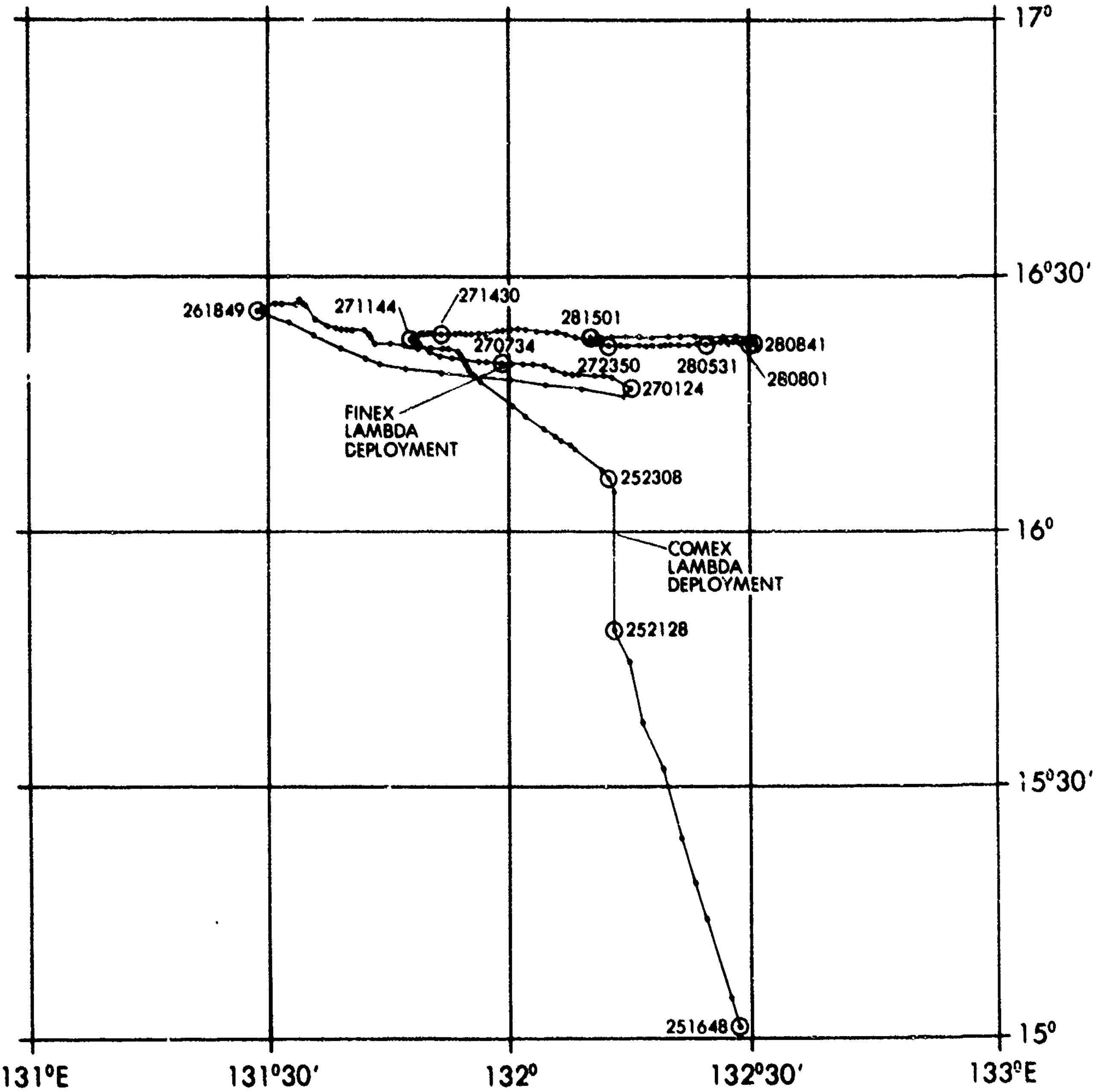



Figure 16 (C). Plot of M/V SEISMIC EXPLORER Phase 1 rectified navigation (U)

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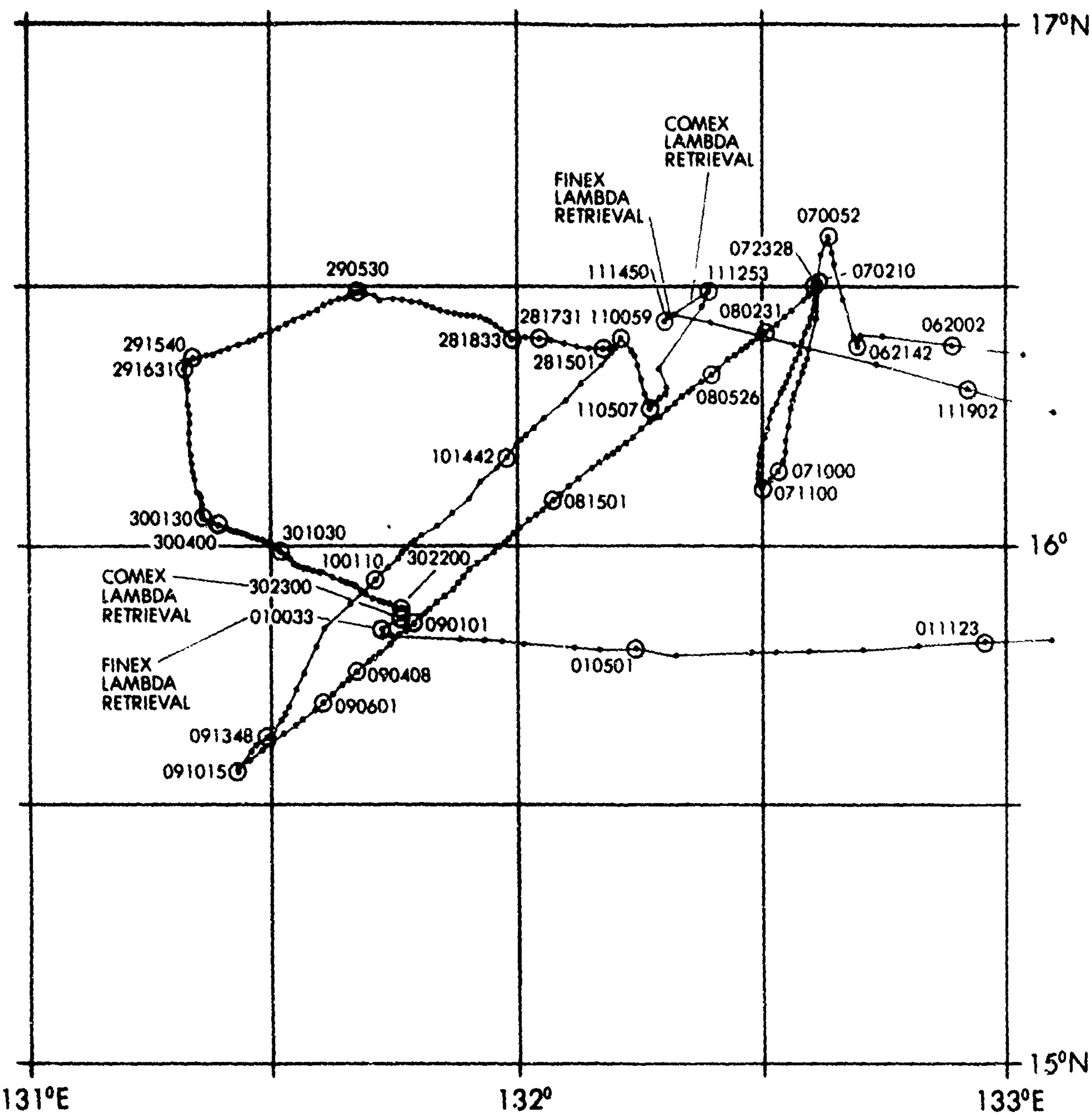


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# TABLE 1 (C)

## TABULATION OF RECTIFIED NAVIGATION POSITIONS FOR M/V SEISMIC EXPLORER (U)

| | EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
|---|---|---|---|---|---|
| | | 7 260N | 134 237E | 1621 | 231177 |
| 20000 → | | 7 260N | 134 237E | 2110 | 231177 |
| | | 7 296N | 134 238E | 2140 | 231177 |
| | | 7 313N | 134 241E | 2149 | 231177 |
| | | 7 331N | 134 254E | 2201 | 231177 |
| | | 7 364N | 134 277E | 2223 | 231177 |
| | | 7 376N | 134 273E | 2231 | 231177 |
| | | 7 381N | 134 255E | 2241 | 231177 |
| | | 7 384N | 134 241E | 2249 | 231177 |
| | | 7 405N | 134 234E | 2301 | 231177 |
| | | 7 556N | 134 196E | 0025 | 241177 |
| | | 8 044N | 134 165E | 0144 | 241177 |
| | | 8 074N | 134 156E | 0201 | 241177 |
| | | 8 174N | 134 130E | 0256 | 241177 |
| | | 8 291N | 134 111E | 0400 | 241177 |
| | | 8 400N | 134 087E | 0500 | 241177 |
| | | 8 509N | 134 059E | 0600 | 241177 |
| | | 9 076N | 134 020E | 0727 | 241177 |
| | | 9 230N | 133 586E | 0848 | 241177 |
| | | 9 373N | 133 550E | 1008 | 241177 |
| | | 9 477N | 133 523E | 1108 | 241177 |
| | | 9 582N | 133 494E | 1208 | 241177 |
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| | | 10 204N | 133 439E | 1408 | 241177 |
| | | 10 311N | 133 406E | 1508 | 241177 |
| | | 10 413N | 133 380E | 1602 | 241177 |
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| | | 10 588N | 133 337E | 1736 | 241177 |
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| | | 11 151N | 133 292E | 1908 | 241177 |
| | | 11 184N | 133 281E | 1926 | 241177 |
| | | 11 224N | 133 270E | 1948 | 241177 |
| | | 11 370N | 133 234E | 2108 | 241177 |
| | | 11 476N | 133 205E | 2208 | 241177 |
| | | 11 580N | 133 177E | 2308 | 241177 |
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| | | 12 408N | 133 062E | 0308 | 251177 |
| | | 12 471N | 133 047E | 0346 | 251177 |
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| | EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
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| | | 14 446N | 132 329E | 1508 | 251177 |
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| | | 14 546N | 132 304E | 1608 | 251177 |
| | | 15 011N | 132 288E | 1648 | 251177 |
| | | 15 047N | 132 277E | 1710 | 251177 |
| | | 15 142N | 132 246E | 1808 | 251177 |
| | | 15 184N | 132 232E | 1834 | 251177 |
| | | 15 239N | 132 216E | 1908 | 251177 |
| | | 15 321N | 132 194E | 1958 | 251177 |
| | | 15 375N | 132 167E | 2028 | 251177 |
| | | 15 447N | 132 144E | 2108 | 251177 |
| | | 15 483N | 132 132E | 2128 | 251177 |
| 20300 → | | 16 048N | 132 132E | 2258 | 251177 |
| | | 16 064N | 132 129E | 2308 | 251177 |
| | | 16 073N | 132 117E | 2328 | 251177 |
| | | 16 098N | 132 081E | 0008 | 261177 |
| | | 16 101N | 132 076E | 0028 | 261177 |
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| | | 16 114N | 132 059E | 0138 | 261177 |
| | | 16 122N | 132 044E | 0158 | 261177 |
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| | | 16 176N | 131 569E | 0408 | 261177 |
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| | | 16 189N | 131 555E | 0456 | 261177 |
| | | 16 198N | 131 548E | 0538 | 261177 |
| | | 16 202N | 131 545E | 0558 | 261177 |
| | | 16 204N | 131 545E | 0608 | 261177 |
| | | 16 205N | 131 545E | 0620 | 261177 |
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| | | 16 228N | 131 429E | 1108 | 261177 |
| | | 16 232N | 131 428E | 1148 | 261177 |
| | | 16 236N | 131 421E | 1208 | 261177 |
| | | 16 237N | 131 405E | 1238 | 261177 |
| | | 16 237N | 131 400E | 1248 | 261177 |
| | | 16 239N | 131 391E | 1308 | 261177 |
| | | 16 240N | 131 387E | 1320 | 261177 |
| | | 16 242N | 131 373E | 1358 | 261177 |
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| | | 16 267N | 131 347E | 1538 | 261177 |
| | | 16 269N | 131 342E | 1548 | 261177 |
| | | 16 270N | 131 341E | 1604 | 261177 |
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| | | 16 268N | 131 337E | 1649 | 261177 |



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| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
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| | 16 245N | 131 326E | 1922 | 261177 |
| | 16 230N | 131 359E | 1954 | 261177 |
| | 16 217N | 131 391E | 2024 | 261177 |
| | 16 204N | 131 422E | 2054 | 261177 |
| | 16 197N | 131 439E | 2110 | 261177 |
| | 16 193N | 131 474E | 2134 | 261177 |
| | 16 187N | 131 517E | 2204 | 261177 |
| | 16 182N | 131 561E | 2234 | 261177 |
| | 16 177N | 132 005E | 2304 | 261177 |
| | 16 171N | 132 048E | 2334 | 261177 |
| | 16 156N | 132 092E | 0004 | 271177 |
| | 16 159N | 132 147E | 0042 | 271177 |
| | 16 168N | 132 153E | 0124 | 271177 |
| | 16 181N | 132 129E | 0204 | 271177 |
| | 16 183N | 132 121E | 0224 | 271177 |
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| | 16 184N | 132 087E | 0324 | 271177 |
| | 16 186N | 132 081E | 0348 | 271177 |
| | 16 188N | 132 074E | 0424 | 271177 |
| | 16 191N | 132 056E | 0504 | 271177 |
| | 16 195N | 132 048E | 0530 | 271177 |
| | 16 195N | 132 033E | 0634 | 271177 |
| | 16 197N | 132 018E | 0640 | 271177 |
| | 16 198N | 132 005E | 0704 | 271177 |
| 21000 | 16 199N | 131 590E | 0734 | 271177 |
| | 16 199N | 131 575E | 0804 | 271177 |
| | 16 200N | 131 567E | 0824 | 271177 |
| | 16 202N | 131 544E | 0904 | 271177 |
| | 16 205N | 131 529E | 0934 | 271177 |
| | 16 208N | 131 515E | 1004 | 271177 |
| | 16 214N | 131 502E | 1034 | 271177 |
| | 16 220N | 131 491E | 1104 | 271177 |
| | 16 224N | 131 484E | 1124 | 271177 |
| | 16 226N | 131 478E | 1144 | 271177 |
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| | 16 231N | 131 488E | 1244 | 271177 |
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| | 16 237N | 132 024E | 1931 | 271177 |
| | 16 235N | 132 036E | 2000 | 271177 |
| | 16 234N | 132 049E | 2031 | 271177 |
| | 16 234N | 132 061E | 2101 | 271177 |
| | 16 232N | 132 073E | 2131 | 271177 |
| | 16 229N | 132 085E | 2201 | 271177 |
| | 16 225N | 132 096E | 2231 | 271177 |
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| | 16 220N | 132 119E | 2331 | 271177 |
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| | 16 217N | 132 150E | 0101 | 281177 |
| | 16 218N | 132 163E | 0134 | 281177 |
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| | 16 218N | 132 183E | 0231 | 281177 |
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| | 16 222N | 132 247E | 0531 | 281177 |
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| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
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| | 16 253N | 131 572E | 2000 | 281177 |
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| | 16 263N | 131 543E | 2200 | 281177 |
| | 16 265N | 131 535E | 2230 | 281177 |
| | 16 266N | 131 527E | 2300 | 281177 |
| | 16 268N | 131 519E | 2330 | 281177 |
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| | 16 271N | 131 501E | 0038 | 291177 |
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| | 16 288N | 131 412E | 0500 | 291177 |
| 22100 | 16 289N | 131 401E | 0530 | 291177 |
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| | 16 215N | 131 202E | 1540 | 291177 |
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| | 16 208N | 131 191E | 1615 | 291177 |
| | 16 203N | 131 189E | 1631 | 291177 |
| | 16 192N | 131 191E | 1710 | 291177 |
| | 16 186N | 131 192E | 1728 | 291177 |
| | 16 177N | 131 193E | 1750 | 291177 |
| | 16 162N | 131 194E | 1831 | 291177 |
| | 16 154N | 131 196E | 1852 | 291177 |
| | 16 140N | 131 196E | 1930 | 291177 |
| | 16 127N | 131 196E | 2001 | 291177 |
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| | 16 076N | 131 202E | 2221 | 291177 |
| | 16 060N | 131 205E | 2317 | 291177 |
| | 16 057N | 131 208E | 2337 | 291177 |
| | 16 055N | 131 209E | 2346 | 291177 |
| | 16 046N | 131 210E | 0015 | 301177 |
| | 16 038N | 131 211E | 0045 | 301177 |
| | 16 033N | 131 211E | 0101 | 301177 |
| 22400 | 16 030N | 131 211E | 0130 | 301177 |
| | 16 029N | 131 217E | 0230 | 301177 |
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| | 16 025N | 131 227E | 0324 | 301177 |
| | 16 022N | 131 234E | 0400 | 301177 |
| | 16 019N | 131 242E | 0448 | 301177 |
| | 16 018N | 131 248E | 0512 | 301177 |
| | 16 017N | 131 251E | 0530 | 301177 |
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| | 16 013N | 131 263E | 0636 | 301177 |
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| | 16 005N | 131 288E | 0836 | 301177 |
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| | 15 593N | 131 308E | 1030 | 301177 |
| | 15 588N | 131 313E | 1100 | 301177 |
| | 15 584N | 131 320E | 1130 | 301177 |
| | 15 577N | 131 323E | 1201 | 301177 |
| | 15 575N | 131 330E | 1231 | 301177 |
| | 15 573N | 131 336E | 1301 | 301177 |
| | 15 572N | 131 343E | 1331 | 301177 |
| | 15 569N | 131 350E | 1401 | 301177 |
| | 15 569N | 131 357E | 1431 | 301177 |
| | 15 567N | 131 364E | 1452 | 301177 |
| | 15 563N | 131 372E | 1531 | 301177 |
| | 15 559N | 131 382E | 1610 | 301177 |
| | 15 558N | 131 388E | 1640 | 301177 |
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| | 15 553N | 131 398E | 1740 | 301177 |
| | 15 550N | 131 402E | 1758 | 301177 |
| | 15 547N | 131 406E | 1824 | 301177 |
| | 15 543N | 131 413E | 1900 | 301177 |
| | 15 540N | 131 420E | 1930 | 301177 |
| | 15 536N | 131 429E | 2010 | 301177 |
| | 15 534N | 131 434E | 2030 | 301177 |

| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
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| | 15 523N | 131 461E | 2244 | 301177 |
| | 15 515N | 131 456E | 2300 | 301177 |
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| | 15 495N | 131 433E | 0044 | 011277 |
| | 15 496N | 131 454E | 0101 | 011277 |
| | 15 493N | 131 528E | 0201 | 011277 |
| | 15 491N | 131 556E | 0222 | 011277 |
| | 15 489N | 131 580E | 0242 | 011277 |
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| | 15 480N | 132 144E | 0501 | 011277 |
| | 15 474N | 132 192E | 0542 | 011277 |
| | 15 478N | 132 283E | 0701 | 011277 |
| | 15 478N | 132 315E | 0728 | 011277 |
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| | 15 481N | 132 423E | 0901 | 011277 |
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| | 15 490N | 132 572E | 1123 | 011277 |
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| | 15 494N | 133 182E | 1404 | 011277 |
| | 15 495N | 133 251E | 1503 | 011277 |
| | 15 495N | 133 269E | 1520 | 011277 |
| | 15 494N | 133 304E | 1550 | 011277 |
| | 15 493N | 133 390E | 1706 | 011277 |
| | 15 493N | 133 409E | 1723 | 011277 |
| | 15 510N | 133 449E | 1803 | 011277 |
| | 15 545N | 133 500E | 1902 | 011277 |
| | 15 588N | 133 550E | 2003 | 011277 |
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| | 16 089N | 134 022E | 2203 | 011277 |
| | 16 143N | 134 056E | 2303 | 011277 |
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| | 16 313N | 134 167E | 0204 | 021277 |
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| | 16 544N | 134 351E | 0622 | 021277 |
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| | 17 586N | 135 351E | 2004 | 021277 |
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| | 17 325N | 135 353E | 0024 | 031277 |
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| | 17 180N | 135 197E | 0304 | 031277 |
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| | 17 024N | 135 076E | 0529 | 031277 |
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| | 17 050N | 135 166E | 0658 | 031277 |
| | 17 069N | 135 222E | 0756 | 031277 |
| | 17 089N | 135 296E | 0906 | 031277 |
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| | 17 227N | 136 319E | 2006 | 031277 |
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| | 17 223N | 136 512E | 2336 | 031277 |
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| | 17 194N | 137 158E | 0348 | 041277 |
| | 17 161N | 137 233E | 0454 | 041277 |
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| | 16 508N | 138 156E | 1407 | 041277 |
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| | 16 414N | 138 395E | 1822 | 041277 |
| | 16 400N | 138 442E | 1912 | 041277 |
| | 16 388N | 138 480E | 2007 | 041277 |
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| | 16 162N | 139 289E | 0258 | 051277 |
| 24000 | 16 124N | 139 327E | 0400 | 051277 |
| | 16 125N | 139 289E | 0422 | 051277 |
| | 16 120N | 139 199E | 0504 | 051277 |
| | 16 126N | 139 081E | 0606 | 051277 |
| | 16 124N | 138 570E | 0704 | 051277 |
| | 16 120N | 138 458E | 0804 | 051277 |
| | 16 116N | 138 345E | 0904 | 051277 |
| | 16 109N | 138 232E | 1004 | 051277 |
| | 16 101N | 138 118E | 1104 | 051277 |
| | 16 095N | 138 008E | 1208 | 051277 |
| | 16 088N | 137 508E | 1300 | 051277 |
| | 16 080N | 137 399E | 1358 | 051277 |
| | 16 078N | 137 354E | 1422 | 051277 |
| | 16 070N | 137 230E | 1526 | 051277 |
| | 16 067N | 137 146E | 1610 | 051277 |
| | 16 061N | 137 022E | 1714 | 051277 |
| | 16 059N | 136 583E | 1734 | 051277 |
| | 16 056N | 136 521E | 1806 | 051277 |
| | 16 054N | 136 417E | 1900 | 051277 |
| | 16 054N | 136 322E | 1952 | 051277 |
| | 16 060N | 136 210E | 2100 | 051277 |
| | 16 069N | 136 118E | 2200 | 051277 |
| | 16 078N | 136 025E | 2300 | 051277 |
| | 16 080N | 135 580E | 2332 | 051277 |
| | 16 083N | 135 534E | 0000 | 061277 |
| | 16 089N | 135 441E | 0100 | 061277 |
| | 16 091N | 135 416E | 0118 | 061277 |
| | 16 096N | 135 339E | 0208 | 061277 |
| | 16 103N | 135 244E | 0310 | 061277 |
| | 16 109N | 135 210E | 0332 | 061277 |
| | 16 111N | 135 174E | 0356 | 061277 |

| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
|---|---|---|---|---|
| | 16 116N | 135 082E | 0456 | 061277 |
| | 16 118N | 135 050E | 0516 | 061277 |
| | 16 123N | 134 566E | 0608 | 061277 |
| | 16 129N | 134 470E | 0710 | 061277 |
| | 16 140N | 134 381E | 0808 | 061277 |
| | 16 154N | 134 301E | 0908 | 061277 |
| | 16 165N | 134 222E | 1008 | 061277 |
| | 16 175N | 134 138E | 1108 | 061277 |
| | 16 181N | 134 053E | 1208 | 061277 |
| | 16 185N | 133 580E | 1300 | 061277 |
| | 16 190N | 133 487E | 1402 | 061277 |
| | 16 194N | 133 437E | 1436 | 061277 |
| | 16 196N | 133 396E | 1502 | 061277 |
| | 16 197N | 133 370E | 1520 | 061277 |
| | 16 201N | 133 278E | 1620 | 061277 |
| | 16 203N | 133 243E | 1642 | 061277 |
| | 16 205N | 133 208E | 1704 | 061277 |
| | 16 213N | 133 114E | 1802 | 061277 |
| | 16 217N | 133 068E | 1832 | 061277 |
| | 16 223N | 133 020E | 1902 | 061277 |
| | 16 234N | 132 531E | 2002 | 061277 |
| | 16 243N | 132 444E | 2102 | 061277 |
| | 16 245N | 132 416E | 2122 | 061277 |
| | 16 230N | 132 414E | 2142 | 061277 |
| | 16 243N | 132 409E | 2202 | 061277 |
| | 16 285N | 132 397E | 2302 | 061277 |
| | 16 325N | 132 385E | 0002 | 071277 |
| | 16 338N | 132 384E | 0022 | 071277 |
| | 16 357N | 132 377E | 0052 | 071277 |
| | 16 335N | 132 369E | 0132 | 071277 |
| | 16 302N | 132 363E | 0210 | 071277 |
| | 16 264N | 132 365E | 0304 | 071277 |
| | 16 227N | 132 354E | 0342 | 071277 |
| | 16 217N | 132 350E | 0404 | 071277 |
| | 16 210N | 132 348E | 0428 | 071277 |
| | 16 202N | 132 346E | 0454 | 071277 |
| | 16 188N | 132 342E | 0532 | 071277 |
| | 16 174N | 132 337E | 0616 | 071277 |
| | 16 168N | 132 335E | 0632 | 071277 |
| | 16 158N | 132 332E | 0702 | 071277 |
| | 16 140N | 132 329E | 0748 | 071277 |
| | 16 122N | 132 326E | 0832 | 071277 |
| | 16 110N | 132 325E | 0902 | 071277 |
| | 16 098N | 132 324E | 0932 | 071277 |
| | 16 089N | 132 317E | 1000 | 071277 |
| | 16 079N | 132 308E | 1030 | 071277 |
| | 16 069N | 132 297E | 1100 | 071277 |
| | 16 073N | 132 293E | 1131 | 071277 |
| | 16 079N | 132 292E | 1204 | 071277 |
| | 16 085N | 132 292E | 1231 | 071277 |
| | 16 094N | 132 293E | 1301 | 071277 |
| | 16 106N | 132 294E | 1331 | 071277 |
| | 16 113N | 132 295E | 1359 | 071277 |

| EVENT | LATITUDE | | LONGITUDE | | TIME (ZULU) | DATE |
|---|---|---|---|---|---|---|
| | 16 | 113N | 132 | 295E | 1403 | 071277 |
| | 16 | 129N | 132 | 301E | 1432 | 071277 |
| | 16 | 136N | 132 | 303E | 1505 | 071277 |
| | 16 | 149N | 132 | 308E | 1530 | 071277 |
| | 16 | 157N | 132 | 311E | 1554 | 071277 |
| | 16 | 165N | 132 | 315E | 1620 | 071277 |
| | 16 | 178N | 132 | 321E | 1701 | 071277 |
| | 16 | 183N | 132 | 324E | 1718 | 071277 |
| | 16 | 190N | 132 | 327E | 1738 | 071277 |
| | 16 | 198N | 132 | 330E | 1801 | 071277 |
| | 16 | 207N | 132 | 334E | 1831 | 071277 |
| | 16 | 216N | 132 | 339E | 1901 | 071277 |
| | 16 | 222N | 132 | 342E | 1922 | 071277 |
| | 16 | 235N | 132 | 346E | 2001 | 071277 |
| | 16 | 245N | 132 | 350E | 2031 | 071277 |
| | 16 | 254N | 132 | 354E | 2101 | 071277 |
| | 16 | 264N | 132 | 358E | 2131 | 071277 |
| | 16 | 274N | 132 | 361E | 2201 | 071277 |
| | 16 | 285N | 132 | 362E | 2231 | 071277 |
| | 16 | 296N | 132 | 363E | 2301 | 071277 |
| | 16 | 303N | 132 | 364E | 2328 | 071277 |
| | 16 | 299N | 132 | 364E | 2347 | 071277 |
| | 16 | 293N | 132 | 360E | 0001 | 081277 |
| | 16 | 284N | 132 | 348E | 0031 | 081277 |
| | 16 | 271N | 132 | 332E | 0114 | 081277 |
| | 16 | 265N | 132 | 325E | 0131 | 081277 |
| | 16 | 255N | 132 | 314E | 0201 | 081277 |
| | 16 | 250N | 132 | 307E | 0218 | 081277 |
| | 16 | 247N | 132 | 302E | 0231 | 081277 |
| | 16 | 239N | 132 | 290E | 0301 | 081277 |
| | 16 | 235N | 132 | 286E | 0314 | 081277 |
| | 16 | 230N | 132 | 279E | 0330 | 081277 |
| | 16 | 226N | 132 | 275E | 0342 | 081277 |
| | 16 | 219N | 132 | 265E | 0406 | 081277 |
| | 16 | 213N | 132 | 256E | 0430 | 081277 |
| | 16 | 204N | 132 | 244E | 0500 | 081277 |
| | 16 | 197N | 132 | 235E | 0526 | 081277 |
| | 16 | 188N | 132 | 221E | 0601 | 081277 |
| | 16 | 180N | 132 | 211E | 0631 | 081277 |
| | 16 | 179N | 132 | 208E | 0642 | 081277 |
| | 16 | 172N | 132 | 201E | 0701 | 081277 |
| | 16 | 164N | 132 | 191E | 0731 | 081277 |
| | 16 | 156N | 132 | 181E | 0801 | 081277 |
| | 16 | 148N | 132 | 171E | 0830 | 081277 |
| | 16 | 141N | 132 | 159E | 0901 | 081277 |
| | 16 | 133N | 132 | 149E | 0931 | 081277 |
| | 16 | 125N | 132 | 139E | 1001 | 081277 |
| | 16 | 118N | 132 | 128E | 1031 | 081277 |
| | 16 | 110N | 132 | 118E | 1101 | 081277 |
| | 16 | 108N | 132 | 115E | 1112 | 081277 |
| | 16 | 103N | 132 | 107E | 1131 | 081277 |
| | 16 | 095N | 132 | 098E | 1201 | 081277 |
| | 16 | 089N | 132 | 089E | 1227 | 081277 |
| | 16 | 076N | 132 | 071E | 1321 | 081277 |
| | 16 | 067N | 132 | 059E | 1401 | 081277 |
| | 16 | 059N | 132 | 050E | 1440 | 081277 |
| | 16 | 053N | 132 | 042E | 1501 | 081277 |
| | 16 | 047N | 132 | 036E | 1530 | 081277 |
| | 16 | 039N | 132 | 026E | 1601 | 081277 |
| | 16 | 035N | 132 | 020E | 1624 | 081277 |
| | 16 | 029N | 132 | 012E | 1652 | 081277 |
| | 16 | 020N | 132 | 001E | 1731 | 081277 |
| | 16 | 013N | 131 | 593E | 1801 | 081277 |
| | 16 | 009N | 131 | 589E | 1816 | 081277 |
| | 16 | 003N | 131 | 583E | 1840 | 081277 |
| | 15 | 599N | 131 | 576E | 1901 | 081277 |
| | 15 | 591N | 131 | 568E | 1931 | 081277 |
| | 15 | 584N | 131 | 559E | 2002 | 081277 |
| | 15 | 578N | 131 | 549E | 2031 | 081277 |
| | 15 | 571N | 131 | 540E | 2101 | 081277 |
| | 15 | 563N | 131 | 532E | 2135 | 081277 |
| | 15 | 556N | 131 | 525E | 2201 | 081277 |
| | 15 | 549N | 131 | 518E | 2231 | 081277 |
| | 15 | 541N | 131 | 508E | 2301 | 081277 |
| | 15 | 534N | 131 | 498E | 2331 | 081277 |
| | 15 | 526N | 131 | 489E | 0001 | 091277 |
| | 15 | 522N | 131 | 485E | 0018 | 091277 |
| | 15 | 518N | 131 | 480E | 0031 | 091277 |
| | 15 | 510N | 131 | 471E | 0101 | 091277 |
| | 15 | 501N | 131 | 460E | 0131 | 091277 |
| | 15 | 492N | 131 | 449E | 0206 | 091277 |
| | 15 | 485N | 131 | 441E | 0226 | 091277 |
| | 15 | 475N | 131 | 428E | 0301 | 091277 |
| | 15 | 471N | 131 | 424E | 0316 | 091277 |
| 26365 | 15 | 467N | 131 | 417E | 0331 | 091277 |
| | 15 | 455N | 131 | 405E | 0408 | 091277 |
| | 15 | 445N | 131 | 393E | 0438 | 091277 |
| | 15 | 438N | 131 | 384E | 0501 | 091277 |
| | 15 | 426N | 131 | 371E | 0536 | 091277 |
| | 15 | 417N | 131 | 360E | 0601 | 091277 |
| | 15 | 410N | 131 | 352E | 0624 | 091277 |
| | 15 | 399N | 131 | 335E | 0701 | 091277 |
| | 15 | 394N | 131 | 328E | 0720 | 091277 |
| | 15 | 381N | 131 | 310E | 0801 | 091277 |
| | 15 | 372N | 131 | 298E | 0831 | 091277 |
| | 15 | 363N | 131 | 284E | 0901 | 091277 |
| | 15 | 352N | 131 | 271E | 0931 | 091277 |
| | 15 | 342N | 131 | 258E | 0959 | 091277 |
| SE24175R | 15 | 338N | 131 | 257E | 1015 | 091277 |
| | 15 | 360N | 131 | 272E | 1200 | 091277 |
| | 15 | 366N | 131 | 276E | 1233 | 091277 |
| | 15 | 377N | 131 | 290E | 1348 | 091277 |
| | 15 | 387N | 131 | 300E | 1442 | 091277 |
| | 15 | 395N | 131 | 309E | 1532 | 091277 |
| | 15 | 404N | 131 | 313E | 1604 | 091277 |
| | 15 | 412N | 131 | 317E | 1630 | 091277 |

| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
|---|---|---|---|---|
| | 15 434N | 131 327E | 1750 | 091277 |
| | 15 453N | 131 338E | 1854 | 091277 |
| | 15 482N | 131 353E | 2031 | 091277 |
| | 15 504N | 131 364E | 2131 | 091277 |
| | 15 531N | 131 395E | 2324 | 091277 |
| | 15 557N | 131 424E | 0110 | 101277 |
| | 15 574N | 131 442E | 0226 | 101277 |
| | 15 584N | 131 451E | 0316 | 101277 |
| | 15 591N | 131 456E | 0350 | 101277 |
| | 15 596N | 131 460E | 0414 | 101277 |
| | 16 004N | 131 467E | 0504 | 101277 |
| | 16 007N | 131 472E | 0534 | 101277 |
| | 16 013N | 131 479E | 0614 | 101277 |
| | 16 022N | 131 499E | 0800 | 101277 |
| | 16 036N | 131 517E | 0931 | 101277 |
| | 16 053N | 131 538E | 1108 | 101277 |
| | 16 072N | 131 554E | 1231 | 101277 |
| | 16 090N | 131 574E | 1354 | 101277 |
| | 16 101N | 131 584E | 1442 | 101277 |
| | 16 115N | 131 598E | 1540 | 101277 |
| | 16 129N | 132 009E | 1628 | 101277 |
| | 16 137N | 132 016E | 1700 | 101277 |
| | 16 147N | 132 030E | 1748 | 101277 |
| | 16 167N | 132 056E | 1934 | 101277 |
| | 16 185N | 132 073E | 2101 | 101277 |
| | 16 210N | 132 099E | 2301 | 101277 |
| | 16 228N | 132 116E | 0014 | 111277 |
| | 16 238N | 132 124E | 0059 | 111277 |
| | 16 224N | 132 137E | 0140 | 111277 |
| | 16 219N | 132 139E | 0204 | 111277 |
| | 16 208N | 132 142E | 0228 | 111277 |
| | 16 191N | 132 148E | 0324 | 111277 |
| | 16 176N | 132 154E | 0414 | 111277 |
| | 16 165N | 132 157E | 0446 | 111277 |
| | 16 159N | 132 160E | 0507 | 111277 |
| | 16 164N | 132 163E | 0531 | 111277 |
| | 16 169N | 132 169E | 0601 | 111277 |
| | 16 175N | 132 179E | 0636 | 111277 |
| | 16 180N | 132 181E | 0655 | 111277 |
| | 16 203N | 132 172E | 0800 | 111277 |
| | 16 275N | 132 222E | 1156 | 111277 |
| | 16 293N | 132 232E | 1253 | 111277 |
| SE27000R | 16 259N | 132 177E | 1450 | 111277 |
| | 16 266N | 132 181E | 1522 | 111277 |
| 27100 | 16 266N | 132 188E | 1536 | 111277 |
| | 16 257N | 132 234E | 1602 | 111277 |
| | 16 232N | 132 337E | 1702 | 111277 |
| | 16 209N | 132 438E | 1800 | 111277 |
| | 16 182N | 132 549E | 1902 | 111277 |
| | 16 156N | 133 054E | 2002 | 111277 |
| | 16 132N | 133 159E | 2102 | 111277 |
| | 16 109N | 133 262E | 2202 | 111277 |
| | 16 087N | 133 361E | 2302 | 111277 |

| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
|---|---|---|---|---|
| | 16 063N | 133 442E | 0004 | 121277 |
| | 16 037N | 133 553E | 0106 | 121277 |
| | 16 011N | 134 087E | 0236 | 121277 |
| | 15 594N | 134 173E | 0320 | 121277 |
| | 15 582N | 134 235E | 0358 | 121277 |
| | 15 555N | 134 342E | 0508 | 121277 |
| | 15 538N | 134 414E | 0550 | 121277 |
| | 15 505N | 134 540E | 0707 | 121277 |
| | 15 495N | 134 576E | 0730 | 121277 |
| | 15 479N | 135 036E | 0807 | 121277 |
| | 15 450N | 135 130E | 0907 | 121277 |
| | 15 424N | 135 224E | 1007 | 121277 |
| | 15 403N | 135 312E | 1102 | 121277 |
| | 15 375N | 135 423E | 1207 | 121277 |
| | 15 357N | 135 495E | 1250 | 121277 |
| | 15 327N | 136 018E | 1402 | 121277 |
| | 15 310N | 136 090E | 1446 | 121277 |
| | 15 301N | 136 126E | 1507 | 121277 |
| | 15 295N | 136 153E | 1524 | 121277 |
| | 15 286N | 136 196E | 1550 | 121277 |
| | 15 271N | 136 267E | 1632 | 121277 |
| | 15 253N | 136 332E | 1710 | 121277 |
| | 15 228N | 136 434E | 1807 | 121277 |
| | 15 202N | 136 530E | 1904 | 121277 |
| | 15 171N | 137 037E | 2007 | 121277 |
| | 15 142N | 137 136E | 2107 | 121277 |
| | 15 115N | 137 236E | 2207 | 121277 |
| | 15 087N | 137 335E | 2307 | 121277 |
| | 15 061N | 137 437E | 0007 | 131277 |
| | 15 035N | 137 536E | 0107 | 131277 |
| | 15 017N | 138 004E | 0146 | 131277 |
| | 15 008N | 138 040E | 0207 | 131277 |
| | 14 599N | 138 072E | 0228 | 131277 |
| | 14 581N | 138 139E | 0310 | 131277 |
| | 14 571N | 138 178E | 0334 | 131277 |
| | 14 558N | 138 234E | 0407 | 131277 |
| | 14 538N | 138 330E | 0507 | 131277 |
| | 14 513N | 138 461E | 0622 | 131277 |
| | 14 496N | 138 536E | 0708 | 131277 |
| | 14 473N | 139 030E | 0808 | 131277 |
| | 14 451N | 139 126E | 0908 | 131277 |
| | 14 428N | 139 224E | 1008 | 131277 |
| | 14 402N | 139 326E | 1108 | 131277 |
| | 14 376N | 139 429E | 1208 | 131277 |
| | 14 356N | 139 545E | 1308 | 131277 |
| | 14 336N | 140 044E | 1408 | 131277 |
| | 14 319N | 140 121E | 1500 | 131277 |
| | 14 287N | 140 236E | 1608 | 131277 |
| | 14 257N | 140 352E | 1708 | 131277 |
| | 14 230N | 140 455E | 1808 | 131277 |
| | 14 205N | 140 555E | 1908 | 131277 |
| | 14 180N | 141 057E | 2008 | 131277 |
| | 14 155N | 141 156E | 2108 | 131277 |

| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
|---|---|---|---|---|
| | 14 130N | 141 254E | 2208 | 131277 |
| | 14 102N | 141 360E | 2316 | 131277 |
| | 14 080N | 141 447E | 0008 | 141277 |
| | 14 056N | 141 551E | 0108 | 141277 |
| | 14 031N | 142 053E | 0208 | 141277 |
| | 14 016N | 142 109E | 0244 | 141277 |
| | 14 006N | 142 150E | 0308 | 141277 |
| | 13 583N | 142 249E | 0406 | 141277 |
| | 13 554N | 142 352E | 0506 | 141277 |
| | 13 526N | 142 452E | 0608 | 141277 |
| | 13 503N | 142 559E | 0708 | 141277 |
| | 13 484N | 143 059E | 0803 | 141277 |
| | 13 459N | 143 158E | 0903 | 141277 |
| | 13 435N | 143 264E | 1003 | 141277 |
| | 13 412N | 143 354E | 1056 | 141277 |
| | 13 405N | 143 386E | 1113 | 141277 |

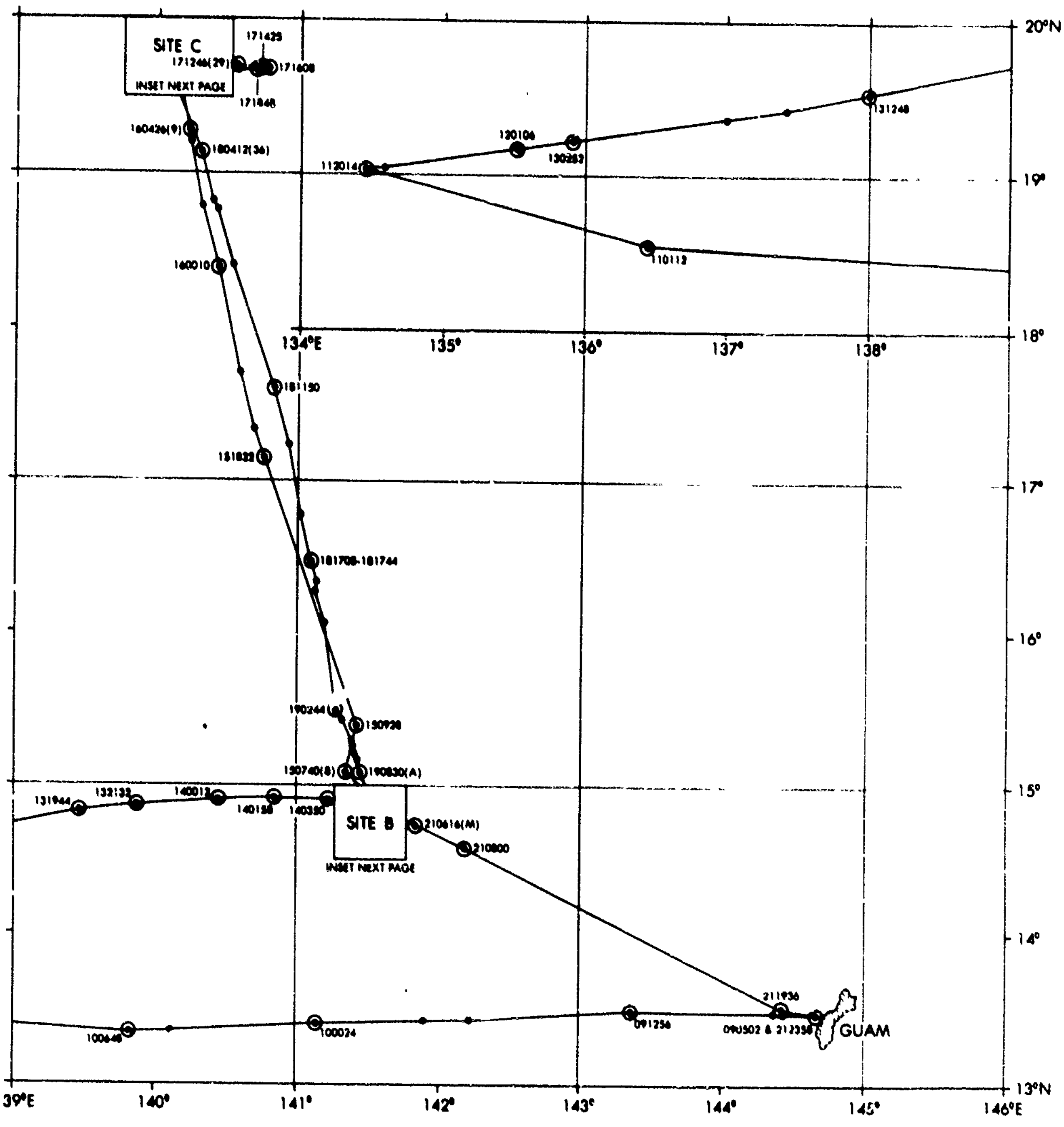
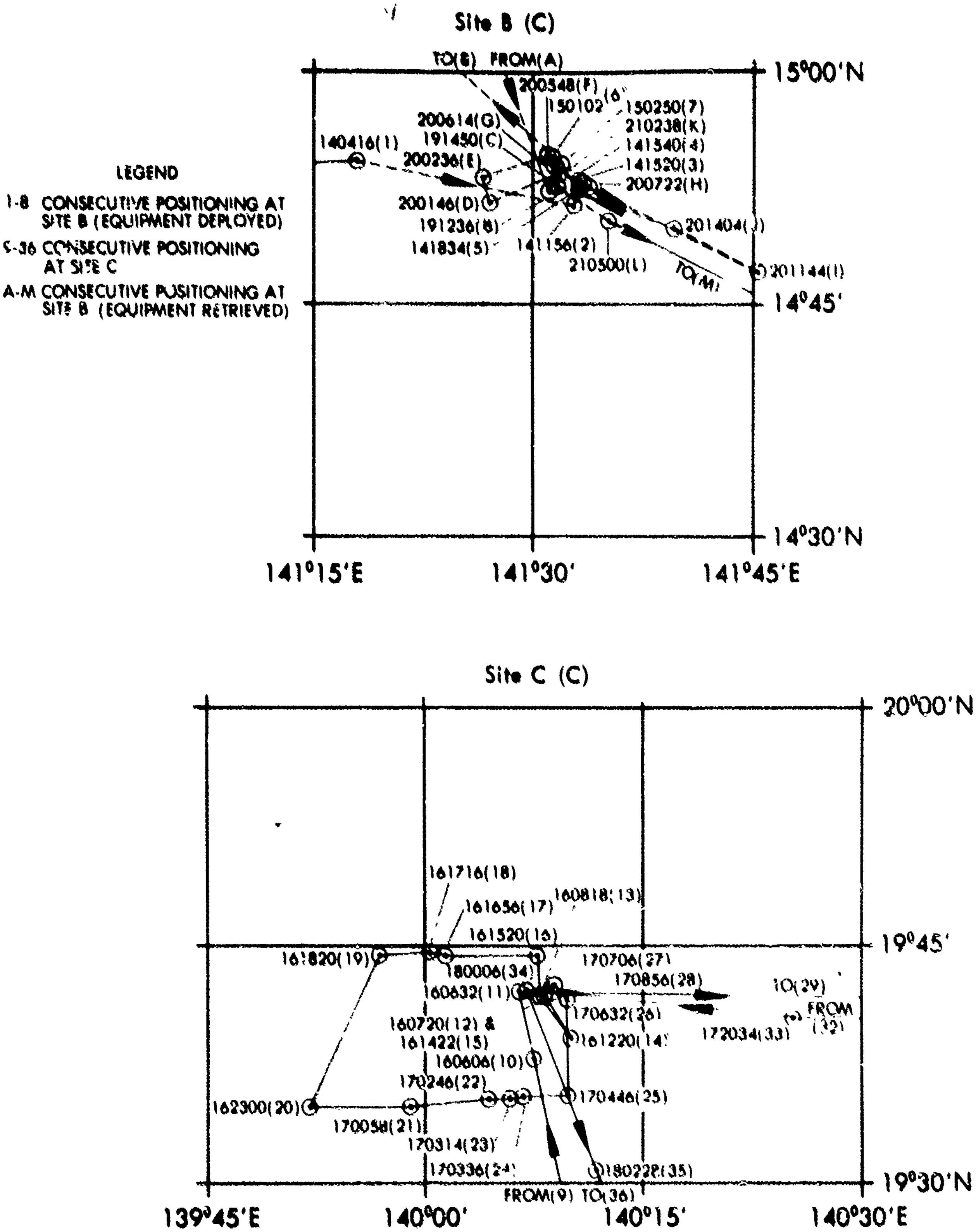



Figure 17 (C). Plot of M/V INDIAN SEAL Phase 1 rectified navigation (U)




Inset to Figure 17 (U)

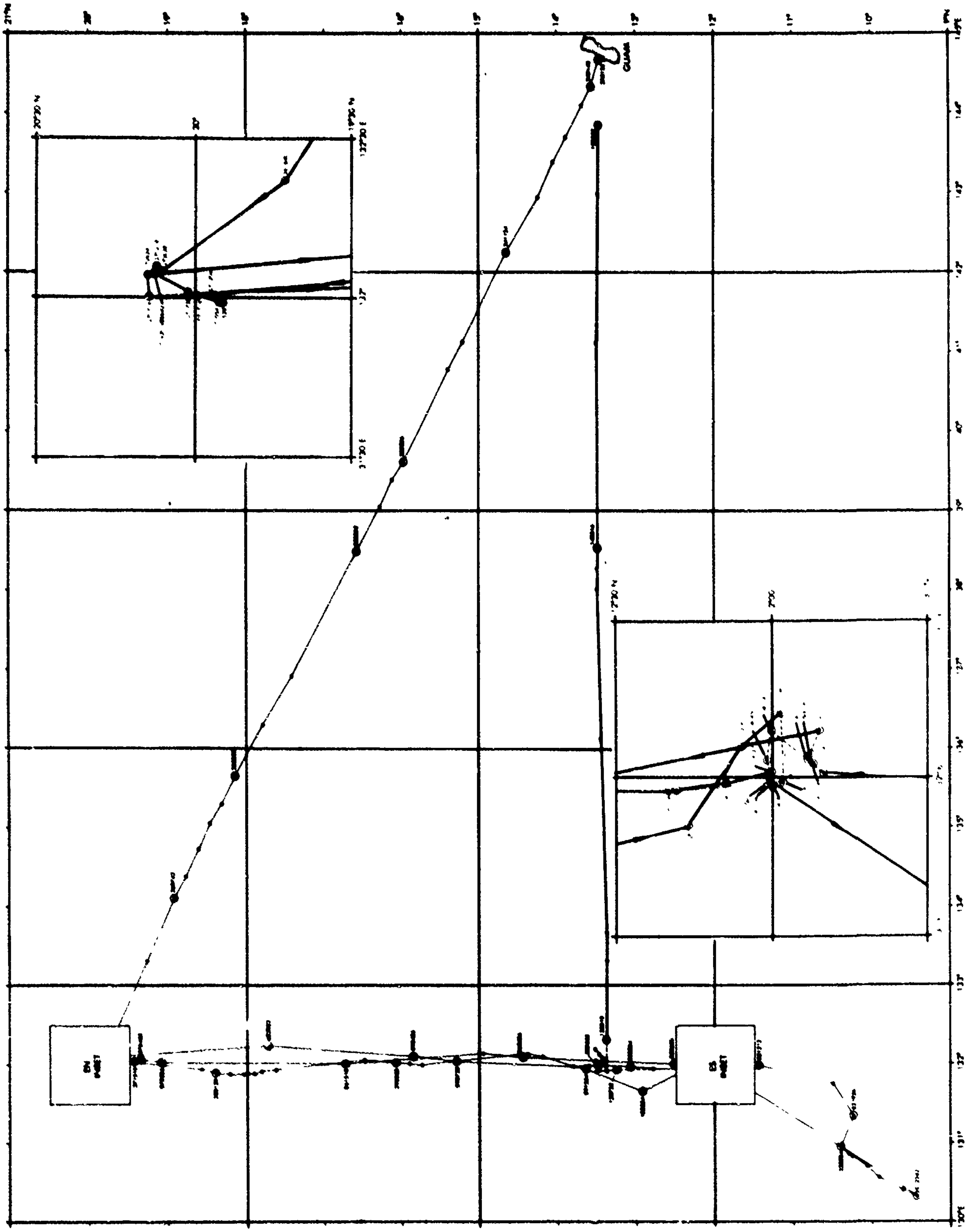



Figure 18 (C). Plot of M/V INDIAN SEAL Phase 2 rectified navigation (U)

TABLE 2 (C)

## TABULATION OF RECTIFIED NAVIGATION POSITIONS FOR M/V INDIAN SEAL (U)

| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
|---|---|---|---|---|
| | 13 277N | 144 396E | 0502 | 091177 |
| 10000 | 13 282N | 144 257E | 0720 | 091177 |
| | 13 281N | 144 218E | 0740 | 091177 |
| | 13 292N | 143 213E | 1256 | 091177 |
| | 13 256N | 142 126E | 1856 | 091177 |
| | 13 254N | 141 533E | 2040 | 091177 |
| | 13 242N | 141 079E | 0024 | 101177 |
| | 13 212N | 140 068E | 0524 | 101177 |
| | 13 209N | 139 497E | 0648 | 101177 |
| | 13 323N | 136 269E | 0112 | 111177 |
| | 14 023N | 134 272E | 2014 | 111177 |
| | 14 036N | 134 354E | 2050 | 111177 |
| | 14 112N | 135 315E | 0106 | 121177 |
| | 14 143N | 135 550E | 0252 | 131177 |
| | 14 271N | 137 008E | 0758 | 131177 |
| | 14 267N | 137 257E | 0958 | 131177 |
| | 14 330N | 138 096E | 1248 | 131177 |
| | 14 493N | 139 287E | 1944 | 131177 |
| | 14 518N | 139 525E | 2132 | 131177 |
| | 14 540N | 140 266E | 0012 | 141177 |
| | 14 545N | 140 500E | 0158 | 141177 |
| | 14 540N | 141 127E | 0350 | 141177 |
| | 14 541N | 141 180E | 0416 | 141177 |
| 10100 | 14 514N | 141 327E | 1156 | 141177 |
| | 14 528N | 141 333E | 1320 | 141177 |
| | 14 530N | 141 331E | 1540 | 141177 |
| | 14 524N | 141 330E | 1834 | 141177 |
| | 14 545N | 141 312E | 0102 | 151177 |
| | 14 541N | 141 319E | 0250 | 151177 |
| 11000 | 15 046N | 141 195E | 0740 | 151177 |
| | 15 233N | 141 242E | 0928 | 151177 |
| | 17 091N | 140 441E | 1822 | 151177 |
| | 17 203N | 140 406E | 1916 | 151177 |
| | 17 426N | 140 348E | 2104 | 151177 |
| | 18 236N | 140 255E | 0010 | 161177 |
| | 18 527N | 140 180E | 0222 | 161177 |
| | 19 123N | 140 132E | 0404 | 161177 |
| | 19 163N | 140 126E | 0426 | 161177 |
| | 19 378N | 140 076E | 0606 | 161177 |
| 11100 | 19 421N | 140 065E | 0632 | 161177 |
| 12000 | 19 418N | 140 079E | 0720 | 161177 |
| | 19 419N | 140 082E | 0818 | 161177 |
| | 19 392N | 140 101E | 1220 | 161177 |
| | 19 418N | 140 079E | 1422 | 161177 |
| | 19 444N | 140 079E | 1520 | 161177 |
| | 19 444N | 140 015E | 1656 | 161177 |
| | 19 445N | 140 006E | 1716 | 161177 |
| | 19 444N | 139 569E | 1820 | 161177 |
| | 19 348N | 139 521E | 2300 | 161177 |
| | 19 348N | 139 590E | 0058 | 171177 |
| | 19 353N | 140 044E | 0246 | 171177 |
| | 19 353N | 140 059E | 0314 | 171177 |
| | 19 355N | 140 068E | 0336 | 171177 |
| | 19 355N | 140 098E | 0446 | 171177 |
| | 19 416N | 140 097E | 0632 | 171177 |
| | 19 425N | 140 088E | 0706 | 171177 |
| 12050 | 19 420N | 140 086E | 0856 | 171177 |
| | 19 417N | 140 324E | 1246 | 171177 |
| | 19 409N | 140 426E | 1428 | 171177 |
| | 19 411N | 140 456E | 1608 | 171177 |
| | 19 405N | 140 430E | 1848 | 171177 |
| | 19 405N | 140 252E | 2034 | 171177 |
| 12100 | 19 422N | 140 070E | 0006 | 181177 |
| | 19 307N | 140 118E | 0228 | 181177 |
| | 19 085N | 140 181E | 0412 | 181177 |
| | 18 499N | 140 226E | 0542 | 181177 |
| | 18 463N | 140 245E | 0602 | 181177 |
| | 18 243N | 140 314E | 0750 | 181177 |
| | 17 364N | 140 489E | 1[illegible]50 | 181177 |
| | 17 145N | 140 551E | 1332 | 181177 |
| | 16 469N | 141 008E | 1538 | 181177 |
| | 16 286N | 141 048E | 1708 | 181177 |
| | 16 285N | 141 048E | 1728 | 181177 |
| | 16 280N | 141 050E | 1744 | 181177 |
| | 16 205N | 141 069E | 1852 | 181177 |
| | 16 166N | 141 068E | 1926 | 181177 |
| | 16 043N | 141 106E | 2114 | 181177 |
| | 15 295N | 141 181E | 0244 | 191177 |
| | 15 257N | 141 189E | 0322 | 191177 |
| | 15 172N | 141 222E | 0450 | 191177 |
| | 15 152N | 141 229E | 0510 | 191177 |
| | 15 128N | 141 237E | 0535 | 191177 |
| | 15 099N | 141 249E | 0638 | 191177 |
| | 15 048N | 141 260E | 0830 | 191177 |
| | 14 523N | 141 310E | 1236 | 191177 |
| 12200 | 14 534N | 141 317E | 1450 | 191177 |
| | 14 516N | 141 270E | 0146 | 201177 |
| | 14 532N | 141 265E | 0236 | 201177 |
| | 14 545N | 141 309E | 0548 | 201177 |
| | 14 539N | 141 312E | 0614 | 201177 |
| | 14 525N | 141 338E | 0722 | 201177 |
| | 14 472N | 141 453E | 1144 | 201177 |
| | 14 509N | 141 396E | 1404 | 201177 |
| 16000 | 14 527N | 141 316E | 0238 | 211177 |
| 16100 | 14 504N | 141 351E | 0500 | 211177 |
| | 14 437N | 141 407E | 0616 | 211177 |
| | 14 346N | 142 101E | 0800 | 211177 |
| | 13 301N | 144 253E | 1936 | 211177 |
| | 13 276N | 144 400E | 2358 | 211177 |
| | 13 277N | 144 400E | 2132 | 231177 |
| 20220 | 13 344N | 144 199E | 0140 | 241177 |
| | 13 414N | 144 054E | 0248 | 241177 |
| | 13 536N | 143 412E | 0440 | 241177 |
| | 14 032N | 143 227E | 0606 | 241177 |
| | 14 143N | 142 559E | 0812 | 241177 |
| | 14 394N | 142 145E | 1134 | 241177 |

| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
|---|---|---|---|---|
| 20220 | 15 127N | 141 088E | 1732 | 241177 |
| | 15 248N | 140 461E | 1946 | 241177 |
| | 15 595N | 139 366E | 0206 | 251177 |
| | 16 072N | 139 225E | 0344 | 251177 |
| | 16 171N | 139 035E | 0518 | 251177 |
| | 16 351N | 136 294E | 0852 | 251177 |
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| | 18 095N | 135 394E | 2350 | 251177 |
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| | 18 279N | 135 030E | 0254 | 261177 |
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| | 18 555N | 134 062E | 0742 | 261177 |
| | 19 160N | 133 181E | 1134 | 261177 |
| 261800 | 19 422N | 132 218E | 1640 | 261177 |
| 262215 | 20 064N | 132 050E | 0038 | 271177 |
| | 20 072N | 132 058E | 0218 | 271177 |
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| | 20 087N | 132 004E | 0716 | 271177 |
| 22070 | 19 253N | 132 024E | 1510 | 271177 |
| | 18 349N | 131 561E | 2344 | 271177 |
| | 18 235N | 131 546E | 0130 | 281177 |
| | 18 126N | 131 527E | 0312 | 281177 |
| | 18 014N | 131 525E | 0500 | 281177 |
| | 17 582N | 131 527E | 0532 | 281177 |
| | 17 532N | 131 529E | 0624 | 281177 |
| | 17 484N | 131 535E | 0714 | 281177 |
| | 17 377N | 131 559E | 0900 | 281177 |
| | 16 291N | 132 028E | 2036 | 281177 |
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| | 14 119N | 132 054E | 1926 | 291177 |
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| | 13 046N | 131 584E | 0834 | 301177 |
| | 12 473N | 131 562E | 1126 | 301177 |
| | 12 181N | 131 575E | 1630 | 301177 |
| 22700 | 12 088N | 131 589E | 1820 | 301177 |
| 22750 | 11 599N | 132 010E | 0032 | 011277 |
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| | 10 040N | 130 419E | 0444 | 021277 |
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| | 10 180N | 130 522E | 0646 | 021277 |
| | 10 240N | 130 570E | 0804 | 021277 |
| | 10 149N | 131 210E | 1936 | 021277 |
| | 10 299N | 131 456E | 0244 | 031277 |
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| 24050 | 13 304N | 132 027E | 1954 | 051277 |
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| | 20 074N | 132 046E | 0642 | 081277 |
| 26100 | 17 431N | 132 146E | 2002 | 081277 |
| 26365 | 15 511N | 132 060E | 0436 | 091277 |
| | 15 177N | 132 011E | 0722 | 091277 |
| | 13 484N | 131 578E | 1444 | 091277 |
| | 13 386N | 131 569E | 1534 | 091277 |
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| | 12 158N | 131 508E | 1930 | 101277 |
| | 12 058N | 132 059E | 0326 | 111277 |
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| | 11 579N | 131 592E | 1822 | 111277 |
| 28050 | 12 199N | 131 573E | 0318 | 121277 |
| | 13 153N | 131 565E | 0732 | 121277 |
| | 13 306N | 131 546E | 1248 | 121277 |
| | 13 240N | 132 042E | 1446 | 121277 |
| | 13 315N | 132 116E | 1632 | 121277 |
| | 13 281N | 132 071E | 1724 | 121277 |
| | 13 222N | 131 546E | 1900 | 121277 |
| | 13 229N | 132 188E | 0010 | 131277 |
| | 13 226N | 133 194E | 0456 | 131277 |
| | 13 221N | 133 403E | 0622 | 131277 |
| | 13 270N | 136 070E | 1756 | 131277 |
| | 13 296N | 138 003E | 0244 | 141277 |
| | 13 297N | 138 160E | 0404 | 141277 |
| | 13 295N | 138 317E | 0516 | 141277 |
| 28220 | 13 303N | 141 066E | 1716 | 141277 |
| | 13 298N | 142 590E | 0154 | 151277 |
| | 13 286N | 143 507E | 0552 | 151277 |
| 28300 | | | | |

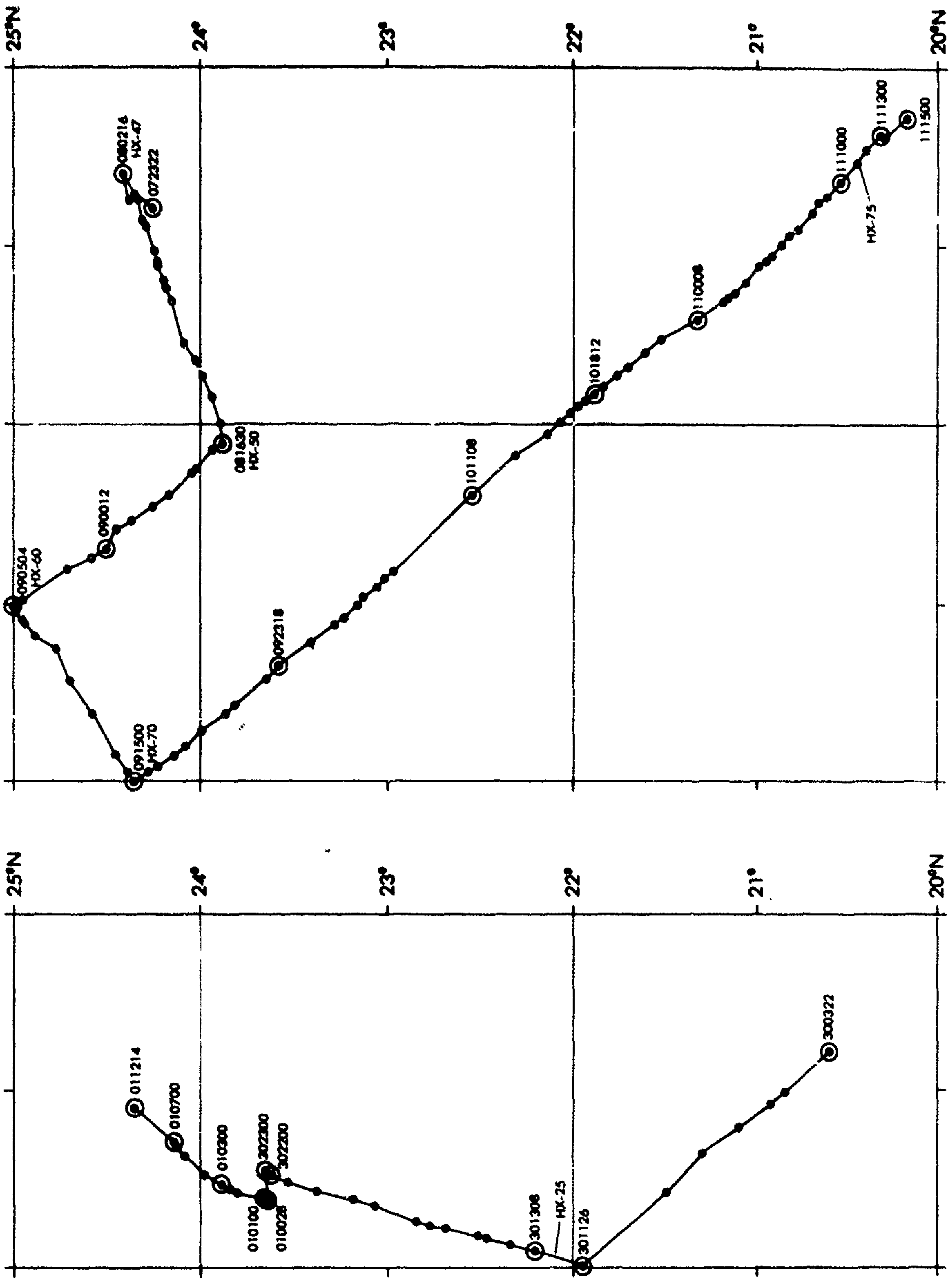


Figure 19 (C). Plot of USS BEAUFORT rectified navigation (U)

## TABLE 3 (C)

## TABULATION OF RECTIFIED NAVIGATION POSITIONS FOR USS BEAUFORT (U)

| EVENT | LATITUDE | LONGITUDE | TIME (ZULU) | DATE |
|---|---|---|---|---|
| | 20 360N | 135 131E | 0322 | 301177 |
| | 20 507N | 134 597E | 0444 | 301177 |
| | 20 557N | 134 557E | 0510 | 301177 |
| | 21 058N | 134 478E | 0600 | 301177 |
| | 21 179N | 134 386E | 0700 | 301177 |
| | 21 295N | 134 252E | 0830 | 301177 |
| 22450 | 21 568N | 134 003E | 1126 | 301177 |
| | 22 124N | 134 051E | 1308 | 301177 |
| | 22 209N | 134 076E | 1400 | 301177 |
| | 22 281N | 134 097E | 1446 | 301177 |
| | 22 305N | 134 103E | 1500 | 301177 |
| | 22 413N | 134 130E | 1604 | 301177 |
| | 22 465N | 134 139E | 1634 | 301177 |
| | 22 510N | 134 152E | 1700 | 301177 |
| | 23 040N | 134 207E | 1822 | 301177 |
| | 23 110N | 134 230E | 1900 | 301177 |
| | 23 226N | 134 256E | 2008 | 301177 |
| | 23 322N | 134 289E | 2100 | 301177 |
| | 23 372N | 134 311E | 2200 | 301177 |
| | 23 393N | 134 326E | 2300 | 301177 |
| | 23 380N | 134 224E | 0028 | 011277 |
| | 23 398N | 134 231E | 0100 | 011277 |
| 22790 | 23 481N | 134 257E | 0216 | 011277 |
| | 23 504N | 134 264E | 0236 | 011277 |
| | 23 532N | 134 282E | 0300 | 011277 |
| | 23 589N | 134 311E | 0352 | 011277 |
| | 24 050N | 134 379E | 0500 | 011277 |
| | 24 074N | 134 404E | 0600 | 011277 |
| | 24 088N | 134 420E | 0700 | 011277 |
| | 24 387N | 134 540E | 1214 | 011277 |
| | 24 154N | 128 117E | 2322 | 071277 |
| | 24 210N | 128 167E | 0100 | 081277 |
| | 24 228N | 128 144E | 0106 | 081277 |
| | 24 246N | 128 232E | 0216 | 081277 |
| | 24 202N | 128 146E | 0402 | 081277 |
| | 24 182N | 128 082E | 0458 | 081277 |
| | 24 173N | 128 056E | 0524 | 081277 |
| | 24 149N | 127 571E | 0634 | 081277 |
| | 24 137N | 127 540E | 0700 | 081277 |
| | 24 135N | 127 526E | 0714 | 081277 |
| | 24 114N | 127 478E | 0800 | 081277 |
| | 24 112N | 127 447E | 0822 | 081277 |
| | 24 089N | 127 410E | 0900 | 081277 |
| | 24 054N | 127 267E | 1112 | 081277 |
| | 24 017N | 127 214E | 1200 | 081277 |
| | 23 594N | 127 153E | 1300 | 081277 |
| | 23 568N | 127 085E | 1400 | 081277 |
| | 23 537N | 127 000E | 1500 | 081277 |
| 23800 | 23 528N | 126 535E | 1630 | 081277 |
| | 23 564N | 126 512E | 1712 | 081277 |
| | 24 015N | 126 447E | 1820 | 081277 |
| | 24 031N | 126 430E | 1838 | 081277 |
| | 24 099N | 126 360E | 2000 | 081277 |
| | 24 155N | 126 318E | 2100 | 081277 |
| | 24 219N | 126 272E | 2200 | 081277 |
| | 24 272N | 126 243E | 2300 | 081277 |
| | 24 305N | 126 176E | 0012 | 091277 |
| | 24 353N | 126 144E | 0100 | 091277 |
| | 24 426N | 126 109E | 0200 | 091277 |
| | 24 570N | 126 001E | 0414 | 091277 |
| | 24 591N | 125 582E | 0440 | 091277 |
| 24100 | 25 007N | 125 581E | 0504 | 091277 |
| | 24 592N | 125 563E | 0530 | 091277 |
| | 24 570N | 125 538E | 0600 | 091277 |
| | 24 561N | 125 526E | 0622 | 091277 |
| | 24 529N | 125 484E | 0712 | 091277 |
| | 24 458N | 125 439E | 0820 | 091277 |
| | 24 418N | 125 335E | 1000 | 091277 |
| | 24 346N | 125 220E | 1200 | 091277 |
| | 24 272N | 125 087E | 1346 | 091277 |
| | 24 234N | 125 026E | 1436 | 091277 |
| 24200 | 24 215N | 124 597E | 1500 | 091277 |
| | 24 162N | 125 025E | 1558 | 091277 |
| | 24 136N | 125 045E | 1622 | 091277 |
| | 24 083N | 125 090E | 1712 | 091277 |
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| | 23 589N | 125 166E | 1852 | 091277 |
| | 23 516N | 125 224E | 2000 | 091277 |
| | 23 491N | 125 255E | 2040 | 091277 |
| | 23 386N | 125 343E | 2200 | 091277 |
| | 23 349N | 125 387E | 2318 | 091277 |
| | 23 249N | 125 468E | 0104 | 101277 |
| | 23 172N | 125 529E | 0226 | 101277 |
| | 23 144N | 125 547E | 0252 | 101277 |
| | 23 099N | 125 592E | 0348 | 101277 |
| | 23 080N | 126 014E | 0412 | 101277 |
| | 23 038N | 126 052E | 0502 | 101277 |
| | 23 010N | 126 077E | 0534 | 101277 |
| | 22 579N | 126 101E | 0608 | 101277 |
| | 22 330N | 126 358E | 1108 | 101277 |
| | 22 189N | 126 493E | 1350 | 101277 |
| | 22 087N | 126 569E | 1534 | 101277 |
| | 22 044N | 127 007E | 1622 | 101277 |
| | 22 014N | 127 037E | 1654 | 101277 |
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| | 21 505N | 127 124E | 1842 | 101277 |
| | 21 458N | 127 162E | 1930 | 101277 |
| | 21 426N | 127 190E | 2000 | 101277 |
| | 21 369N | 127 240E | 2100 | 101277 |
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| | 21 199N | 127 351E | 0008 | 111277 |
| | 21 118N | 127 405E | 0138 | 111277 |
| | 21 099N | 127 421E | 0200 | 111277 |
| | 21 079N | 127 435E | 0226 | 111277 |

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| | 21 039N | 127 475E | 0300 | 111277 |
| | 21 009N | 127 525E | 0408 | 111277 |
| | 20 576N | 127 540E | 0444 | 111277 |
| | 20 555N | 127 562E | 0506 | 111277 |
| | 20 522N | 128 000E | 0558 | 111277 |
| | 20 500N | 128 031E | 0632 | 111277 |
| | 20 466N | 128 055E | 0700 | 111277 |
| | 20 419N | 128 110E | 0800 | 111277 |
| | 20 401N | 128 143E | 0834 | 111277 |
| | 20 372N | 128 165E | 0900 | 111277 |
| 28250 ► | 20 326N | 128 219E | 1000 | 111277 |
| | 20 270N | 128 281E | 1100 | 111277 |
| | 20 244N | 128 322E | 1154 | 111277 |
| 27080 ► | 20 191N | 128 379E | 1200 | 111277 |
| | 20 185N | 128 362E | 1340 | 111277 |
| | 20 109N | 128 433E | 1500 | 111277 |



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(C) During the period from 9 November to 16 December 1977, 160 XBTs and 127 AXBTs were deployed during Cruise 5 of the CHURCH STROKE II Exercise, which took place in the Philippine Sea. Analyses of sound speed conditions along the exercise baseline (12°-20°N along 132°E) indicate that the presence of Typhoon Lucy during the exercise had only a minimal effect on the oceanographic environment, owing primarily to deep mixing resulting from three previous typhoons and one tropical storm that traversed

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) the area in four months. The largest oceanographic variation occurred between the southern and northern extremes of the baseline in the thermocline area where a difference of 21.8 m/sec in sound speed was observed. This variability is attributed to the presence of an upwelling area centered at 7°N at approximately the same latitude as the baseline. Oceanographic variation is evaluated along an acoustic projector tow which took place on the continental shelf and trench areas of the southern Ryukyu Island arc.

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