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CHURCH OPAL EXERCISE SUMMARY (U)

Contract No. N00014-75-C-0126



Prepared by:
XONICS, INC.
for

LONG RANGE ACOUSTIC PROPAGATION PROJECT

Code 107-05C
Office of Naval Research
Arlington, Virginia 22217
SEPTEMBER 1975

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EXERCISE SUMMARY (U).**

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PREFACE (U)

(U) This document is a summary of the CHURCH OPAL Exercise. The CHURCH OPAL Exercise Plan (U), August 1975 (Secret), contains the details of the Exercise operations and data acquisition. The CHURCH OPAL Data Analysis Plan (U), September 1975 (Secret), contains the details of the data analysis.

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1. INTRODUCTION (U)

(C) The CHURCH OPAL Exercise is one of a series of LRAPP Exercises specifically designed to acquire environmental acoustic data required for ASW program decisions. It will be conducted during September 1975 in a region of the Northeast Pacific Ocean, ~~(Figure 1)~~ in accordance with the CHURCH OPAL Exercise Plan (U), August 1975 (Secret).

~~(C)~~ This Exercise includes the following ocean acoustic experiments related to the Moored Surveillance System (MSS), the Sound Surveillance System (SOSUS), and the Surveillance Towed Array Sonar System (SURTASS):

- (1) Noise Floor Characteristics,
- (2) ASEPS Evaluation, Inter-Array Coherent Processing, and
- (3) Horizontal Directionality of Ambient Noise, Towed Array Performance.

(C) The objective of the Noise Floor experiment is to establish the characteristics, persistence, and geographic extent of the low frequency ambient noise floor. The noise floor is a depth below which distant shipping noise is dramatically reduced, thereby providing the opportunity for short range acoustic sensors to attain a substantial performance gain. The objectives of the second experiment relate to the evaluation of the propagation model component of the Automated Signal Excess Prediction System (ASEPS) and to an evaluation of signal coherence properties with respect to inter-array processing algorithms using SOSUS and SURTASS. The third experiment addresses the measurement of horizontal directionality of ambient noise and the assessment of towed array performance as it relates to narrow beam noise threshold and variability.

(C) The CHURCH OPAL Exercise will draw deliberately on the 1973 CHURCH ANCHOR Exercise, thereby improving ASW acoustic prediction capability in the Northeast Pacific Ocean.

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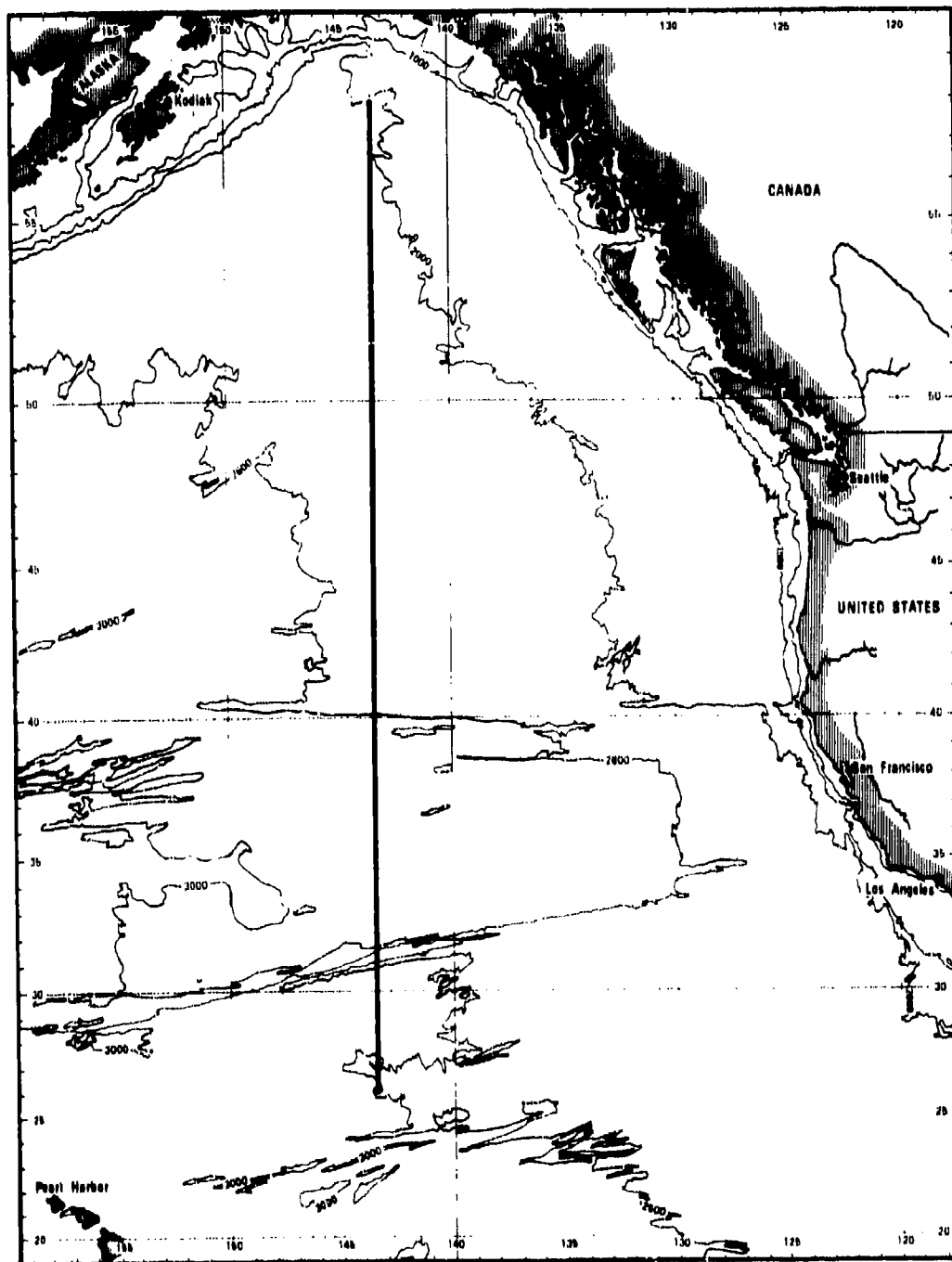


Figure 1. (C) CHURCH OPAL Exercise Baseline (U)

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1.1 Exercise Measurement Systems (U)

(C) The acoustic measurement systems for the Exercise include the Large Aperture Marine Basic Data Array (LAMBDA) system and two Acoustic Data Capsule (ACODAC) systems. The primary CW acoustic energy source will be the Vibroseis system, and the secondary source will be the Honeywell HX-231-F. Expandable bathythermographs (XBT) and airborne XBTs (AXBt), Salinity-Temperature-Depth and Sound Speed (STD/SV) systems, Airborne Radiation Thermometer (ART), and bathymetry recording systems will be used for environmental measurements.

(S) The LAMBDA system is a wide-aperture, narrow beam, compound towed array system 2,438 meters in overall active length. There are three arrays in the compound array. The LAMBDA system has an onboard data processing and analysis capability.

(C) The ACODAC system is a bottom-moored, vertically suspended hydrophone array recording system. The system is self-contained. Its principal components are the subsurface buoy (suspension), recording and power module, hydrophone array, acoustic release, backup time release, and bottom moor. The ACODAC system can be preprogrammed for recording on selected duty cycles. Hydrophone depths are preselected.

(C) The Vibroseis system consists of two towed CW acoustic energy sources. The transducers are two 122-cm diameter hemispheres connected by a servo-controlled hydraulic ram that moves the hemispheres, thereby creating spherical acoustic pressure waves. The primary frequency range is 10 to 100 Hz at a maximum source level range of 190 dB// μ Pa. The frequency range can be extended to 250 Hz at reduced power output levels. The Vibroseis system is programmable in both frequency and duty cycle. The transducers can be towed at selected depths to a maximum depth of 100 meters.

(C) The Honeywell HX-231-F CW projector is a towed acoustic source with a resonant frequency of 104 Hz. The transducer is a ceramic bender bar and produces a maximum source level of 192 dB// μ Pa at the resonant frequency. The HX-231-F is the backup source.

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(C) The DELTA array is a lightweight, mechanically floating, stationary system. It has a 14-element array with a 38.1-meter element spacing that is the same as the LAMBDA low frequency array. Tension is maintained on the array by means of a buoyed drag parachute attached to one end and a weighted cable that passes over a buoyed sheave attached to the other end. The array can be deployed for up to 6 hours. Acoustic and array status information can be telemetered via an RF link or recorded aboard a tethered small boat.

(C) The WARF and SEA ECHO over-the-horizon (OTH) radar systems will be used for surface shipping surveillance in specified areas during the Exercise. Aircraft flights for surface shipping surveillance will also be used.

(S) Acoustic data will be recorded from 1321, 1322, 1323, and 2411 during selected Exercise events using R&D recorders. Station recorders will be used to obtain limited data from 1321, 1322, 1323, 1511, 2321, and 2411 during specified periods of the Exercise.

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1.2 Exercise Participants (U)

(C) The Commands, Laboratories, and Organizations participating in this Exercise are as follows:

Commands

Chief of Naval Operations (OP-095)
Commander in Chief, U. S. Pacific Fleet (CINCPACFLT)
Commander, Third Fleet (COMTHIRDFLT)
Commander, Oceanographic System Pacific (COMOCEANSYSPAC)
Commander, Patrol Wings Pacific (COMPATWINGSPAC)
Manager, ASW Systems Project (MASWSP)
Oceanographer of the Navy (OCEANAV)
Chief of Naval Research (CNR)
Commander, Military Sea Lift Command Pacific (COMSCPAC)

Laboratories

Acoustic Environmental Support Detachment (AESD)
Naval Oceanographic Office (NAVOCEANO)
Naval Research Laboratory (NRL)
Naval Undersea Center, San Diego (NUC)

Civilian Institutions and Contractors

Applied Research Laboratories, University of Texas (ARL/UT)
Delta Seiscom, Inc. (DELTA)
Hawaii Institute of Geophysics (HIG)
Lockheed Missiles and Space Company (LMSC)
Planning Systems, Inc. (PSI)
Seismic Engineering Company (SECO)
Stanford Research Institute (SRI)
Texas Instruments, Inc. (TI)
Tracor, Inc. (Tracor)
Underwater Systems, Inc. (USI)
University of Miami (UM)
Xonics, Inc. (Xonics)

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1.3 Exercise Resources and Operating Organizations (U)

(C) The major resources participating in this Exercise are summarized as follows:

<u>Ships</u>	<u>Operating Organization</u>
R/V MOANA WAVE	HIG
M/V SEISMIC EXPLORER	NUC
M/V AMERICAN DELTA II	DELTA

<u>Aircraft</u>	<u>Operating Organization</u>
1 P-3A	VXN-8
2 P-3C	COMPATWINGSPAC

<u>Acoustic Sources</u>	<u>Responsible Organization</u>	<u>Deploying Units</u>
Vibroseis	DELTA	AMERICAN DELTA II
Honeywell HX-231-F	NUC	MOANA WAVE

<u>Measurement Systems</u>	<u>Responsible Organization</u>	<u>Deploying Units</u>
LAMBDA	NUC	SEISMIC EXPLORER
ACODAC	TI	MOANA WAVE
DELTA Array	LMSC	MOANA WAVE
STD/SV Systems	HIG NUC	MOANA WAVE SEISMIC EXPLORER
XBT	NAVOCEANO	All Ships
ART	NAVOCEANO	P-3A Aircraft
AXB T	NAVOCEANO	P-3A Aircraft
WARF	SRI	
SEA ECHO	NRL	

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Shore Facilities

Naval Base, San Diego

Naval Base, Pearl Harbor

Naval Air Station, Barbers Point

Naval Air Station, Moffett Field

Elmendorf Air Force Base, Anchorage

Shore Station, Centerville Beach

Shore Station, Barbers Point

Shore Station, Pacific Beach

Shore Station, Midway

Fleet Weather Central, Pearl Harbor

Fleet Numerical Weather Central, Monterey

WARF OTH Radar, Los Banos

SEA ECHO OTH Radar, San Clemente Island

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1.4 Exercise Overview (U)

(C) The M/V SEISMIC EXPLORER will deploy the LAMBDA array, which will make signal propagation, coherence, and noise directionality measurements at four locations. The M/V AMERICAN DELTA II will deploy the Vibroseis, which will transmit CW signals for the propagation and coherence measurements. The R/V MOANA WAVE will deploy ACODACs at two locations, and then recover and redeploy one of them at a third location. The ACODACs will make noise and signal propagation measurements at 13 depths. The MOANA WAVE will also make a series of environmental measurements, and will also make four deployments of the DELTA array. A VXN-8 P-3A aircraft will make 12 environmental (ART and AXBT) and shipping surveillance flights. Two COMPATWINGSPAC VP aircraft will make two shipping surveillance flights each. The WARF and SEA ECHO over-the-horizon (OTH) radar systems will conduct surveillance and surface shipping in limited areas during this Exercise. Several shore stations will monitor selected Exercise events.

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2. EXERCISE OPERATIONS AND EVENTS (U)

(C) The three experiments are integrated into the Exercise in a manner that provides maximum utility of the measurement resources. The data acquisition for an individual experiment is accumulated through a series of Exercise events. All events do not necessarily pertain to all three experiments simultaneously. Events pertinent to each major experiment are given in this section.

(C) Figure 2 shows the overall operations schedule. The Exercise will be conducted during September 1975. Three ships (AMERICAN DELTA II, SEISMIC EXPLORER, MOANA WAVE), one VXN-8 P-3A aircraft, and two Fleet P-3C aircraft will participate in the Exercise.

(C) AMERICAN DELTA II will depart from San Diego and will deploy the Vibroseis CW sources on a number of tracks along the Exercise baseline, and will conclude its activities in Kodiak, Alaska.

(C) SEISMIC EXPLORER will depart from San Diego and deploy the LAMBDA array at sites $\lambda 1$, $\lambda 2$, λA , and λB . LAMBDA will be used to make signal propagation, noise directionality, coherence and beam noise fluctuations, and statistics measurements. At the conclusion of the LAMBDA measurements, SEISMIC EXPLORER will transit to Honolulu.

(C) MOANA WAVE will depart from San Diego and deploy ACODACs at A1 and A3. She will deploy the DELTA array at λB and operate the HX source for array deformation measurements. MOANA WAVE will recover the ACODAC at A1 and deploy it at A2. She will then deploy the DELTA array at λB and operate the HX source for array deformation measurements. MOANA WAVE will make environmental measurements, including STD/SVs and XBTs, throughout the Exercise. At the conclusion of the HX source operations, MOANA WAVE will transit to Honolulu. After a short stay in Honolulu, she will recover the ACODACs at A2 and A3 and transit to San Diego.

(C) VXN-8 P-3A aircraft will make 12 flights for environmental measurements and surface shipping surveillance during the Exercise. VXN-8 will operate from NAS Moffett Field, NAS Barbers Point, and Elmendorf AFB. Fleet P-3C aircraft will make four shipping surveillance flights from NAS Barbers Point.

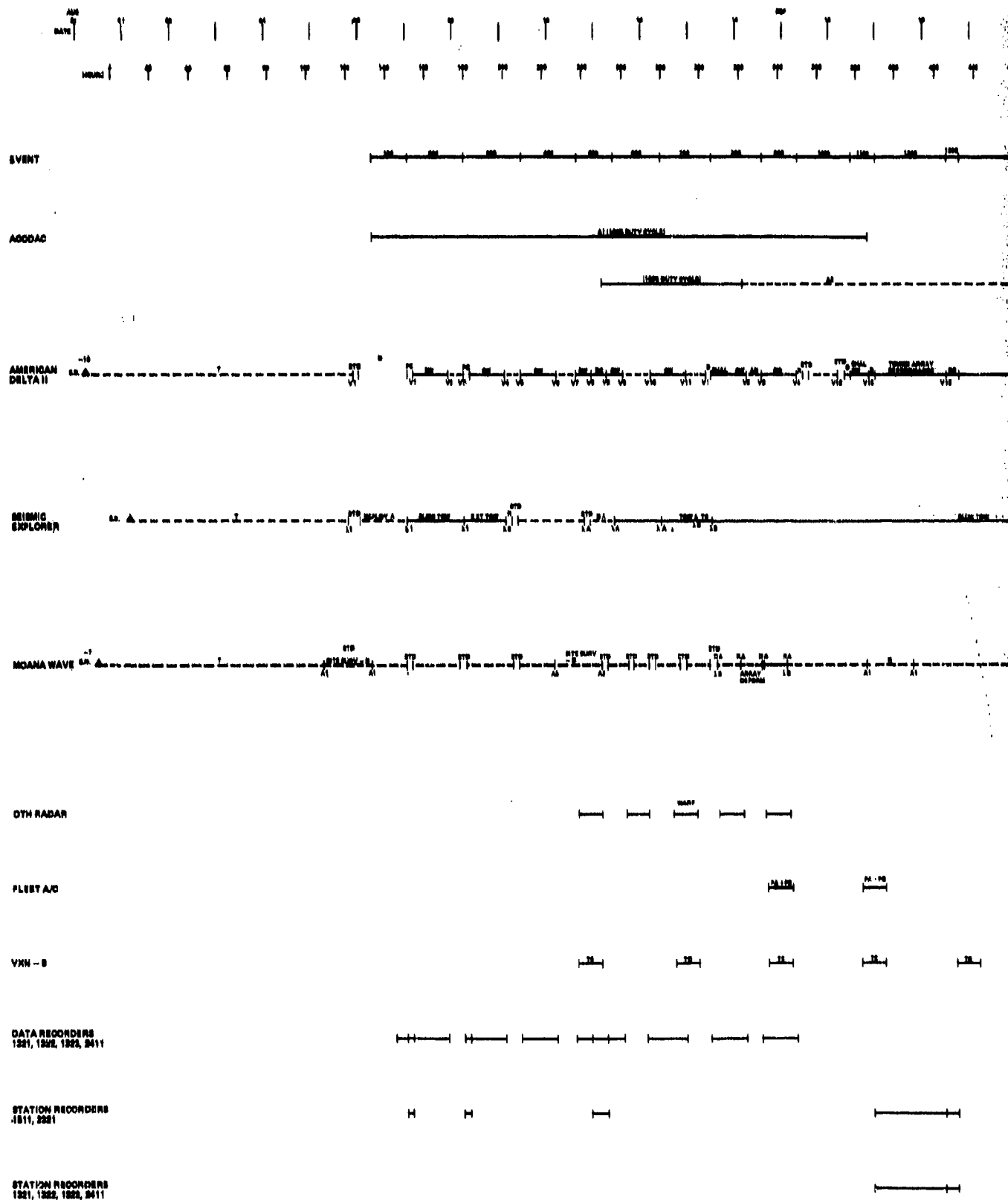
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(C) The WARF and SEA ECHO, over-the-horizon (OTH) radars, will be used for surface shipping surveillance in limited portions of the Exercise area on 5 separate days each.

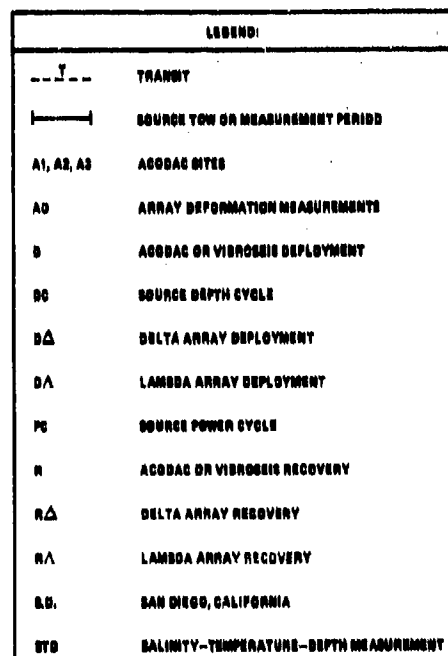
(C) Data from 1321, 1322, 1323, and 2411 will be recorded during selected Exercise events. Stations recorders will be used to obtain limited data from 1321, 1322, 1323, 1511, 2321, and 2411 during selected events.

(C) The Exercise activities will be concentrated along the CHURCH ANCHOR baseline (143°30'W). The measurement sites not on the CHURCH ANCHOR baseline are Sites A1 and A2 for additional noise floor measurements, and Sites λ1 and λ2 for propagation measurements in conjunction with A1.

(C) The Exercise consists of 25 major events that are summarized in Table A. This table includes the measurement systems used for each event and the primary and secondary measurement objectives of each event. Participating measurement systems are indicated by the letter X. The LAMBDA measurement sites are indicated. VXN-8 aircraft flights are denoted by T followed by the flight sequence designation. VP aircraft flights are denoted by P followed by the flight sequence designation. The primary measurement objectives are indicated by the letter P, and the secondary measurement objectives are indicated by the letter S.



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Table A (C) Exercise Event Summary (U)

Event No.	Description	PARTICIPATING UNITS										MEASUREMENT OBJECTIVES				
		Vibracells	LAMBDA	DELTA	A1	A2	A3	Shore Station	Aircraft	OTH	Noise Floor	ASEPS	Inter-Array	SOSUS/LAMBDA	Noise Directionality	Towed Array Performance
100	Ambient Noise Measurement				X							P				
200	NUC 3-Hour Power Cycle at V1 CW TOW From V1 to V2	X	λ1		X			X			P	P	P	P	S	S
300	Stationary CW Transmission at V3, CW TOW V3 to V4	X	λ1-λ2		X			X			P	P	P	P		S
400	CW TOW V5 to V6	X			X			X	TC		P	P				
500	CW TOW V7 to V8, Depth Cycle at V8, CW TOW V8 to V9	X			X			X			P	P				
600	LAMBDA Measurements at λA CW TOW V10 to V11	X	λA		X		X	X	TD	X	P	P		S	P	P
700	CW TOW V10 to V11 Continued LAMBDA in transit	X			X		X	X		X	P	P				
800	CW TOW V1 to V2, DELTA array Deployment, Array Deformation	X	λB		X		X	X	PA PB	X	P	P	S	S	P	P
900	CW TOW V3 to V4, DELTA Array Deployment	X	λB	X	X		X	X	TE PA PB	X	P	S	S	S	P	
1000	LAMBDA Beam noise Measurements		λB		X		X	X		X	P					P
1100	CW TOW V12 to V13	X	λB		X		X	X			P	S				P
1200	Towed Array Performance Sequence	X	λB				X	X	TC		P	S				P
1300	Depth Cycle at V13	X	λB				X	X			P	P				P
1400	CW Tow from V13 to V15	X	λB				X	X	TA		P	P				P
1500	Towed Array Performance Sequence	X	λB			X	X	X	TH		P	S				P
1600	Depth Cycle at V15	X	λB			X	X	X			P	P				P
1700	DELTA Array Deployments, CW TOW V15 to V16	X	λB	X		X	X	X	TA		P	S			P	
1800	CW Tow V17 to V17A	X	λB			X	X	X			P	S				

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Table A (C) Exercise Event Summary (U) (Cont'd)

		PARTICIPATING UNITS										MEASUREMENT OBJECTIVES					
		Vibrosels	LAMBDA	DELTA	A1	A2	A3	Shore Station	Aircraft	OTH	Noise Floor	ASRPS	Inter-Array	SOSUS/LAMBDA	Noise Directionality	Towed Array Performance	
Event No.	Description																
1900	LAMBDA Array Deformation Measurements		AB			X	X	X	TA		P				P	P	
2000	Depth Cycle at V17A	X				X	X	X			P	P					
2100	CW Tow V17A to V17B	X				X	X	X	TJ		P	P					
2200	Shallow Tows and Depth Cycle at V18	X				X	X	X	TA		P	P					
2300	Shallow CW Tows and Depth Cycle at V19	X				X	X	X			P	P					
2400	Shallow CW Tows and Depth Cycle at V20	X				X	X	X			P	P					
2500	Noise Floor Measurements					X	X		TA		P						

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3. EXPERIMENT DESCRIPTIONS (U)

(C) The CHURCH OPAL Exercise includes the following three ocean acoustic experiments related to the Moored Surveillance System (MSS), the Sound Surveillance System (SOSUS), and the Surveillance Towed Array Sonar System (SURTASS):

- o Noise Floor Characteristics
- o ASEPS Evaluation; Inter-Array Coherent Processing
- o Horizontal Directionality of Ambient Noise; Towed Array Performance

Sufficient environmental and shipping surveillance data for adequate analysis of the three acoustic experiments will also be obtained.

(U) A description of each experiment and the supporting environmental and shipping surveillance studies is contained in the following sections. In each section, the discussion includes:

- o Technical Objectives
- o Field Operations
- o Data Acquisition
- o Analyses

3.1 Noise Floor Characteristics (U)

(C) During the CHURCH ANCHOR Exercise, some unusually low levels of low frequency ambient noise were measured on bottomed and near-bottom hydrophones. This effect subsequently led to the development of an experimental model based on the concept of a "noise floor," a depth below which the noise from distant shipping is severely attenuated by high bottom loss and/or bathymetric obstruction. Where the water depth exceeds that of the noise floor, ambient noise levels are expected to be unusually low, such that surface-generated wind noise will dominate even at frequencies as low as 10 Hz or less.

(C) The noise floor can be of great significance for surveillance systems using bottomed or near-bottom sensors such as MSS, i.e., systems that by design are intended to function at relatively short ranges. For this reason, it is

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of interest to obtain additional measurements to verify the noise floor concept and to increase the understanding of this phenomenon.

(C) Data from the CHURCH ANCHOR Exercise were suggestive of the noise floor, but were insufficient to quantitatively characterize the phenomenon. The coherence properties of this noise have also not been measured.

3.1.1 Technical Objectives (U)

(C) The technical objectives of this experiment are listed below in order of priority:

- o Parameterization of the noise below the floor with depth, frequency, and wind speed. Measurements allow the comparison of the noise level below the floor at three widely separated locations. Three-dimensional plots of noise level versus depth and frequency will be developed for high and low values of surface windspeed. These plots will determine the depth intervals and frequency bands in which the noise floor exists.
- o Evaluation of noise model predictions. The noise floor data will be compared with the noise model predictions.

3.1.2 Field Operations (U)

(C) For the noise floor experiment, three ACODAC sites have been selected based upon noise floor depth predictions and compatibility with other experiments; Figure 3 shows the location of the ACODAC sites, and Figure 4 shows the location of the CW tows intended to simulate distant shipping. (Figures 3 through 11 contain a list of the events associated with the experiments related to each figure.)

(C) The ACODAC hydrophone depths are listed in Table B. Each hydrophone string includes two broadband hydrophones to record wind noise above the shipping noise spectrum.

3.1.3 Data Acquisition (U)

(C) For this experiment, all data will be recorded by the ACODAC tape recorder and processed post-exercise. Two Mod II ACODAC systems

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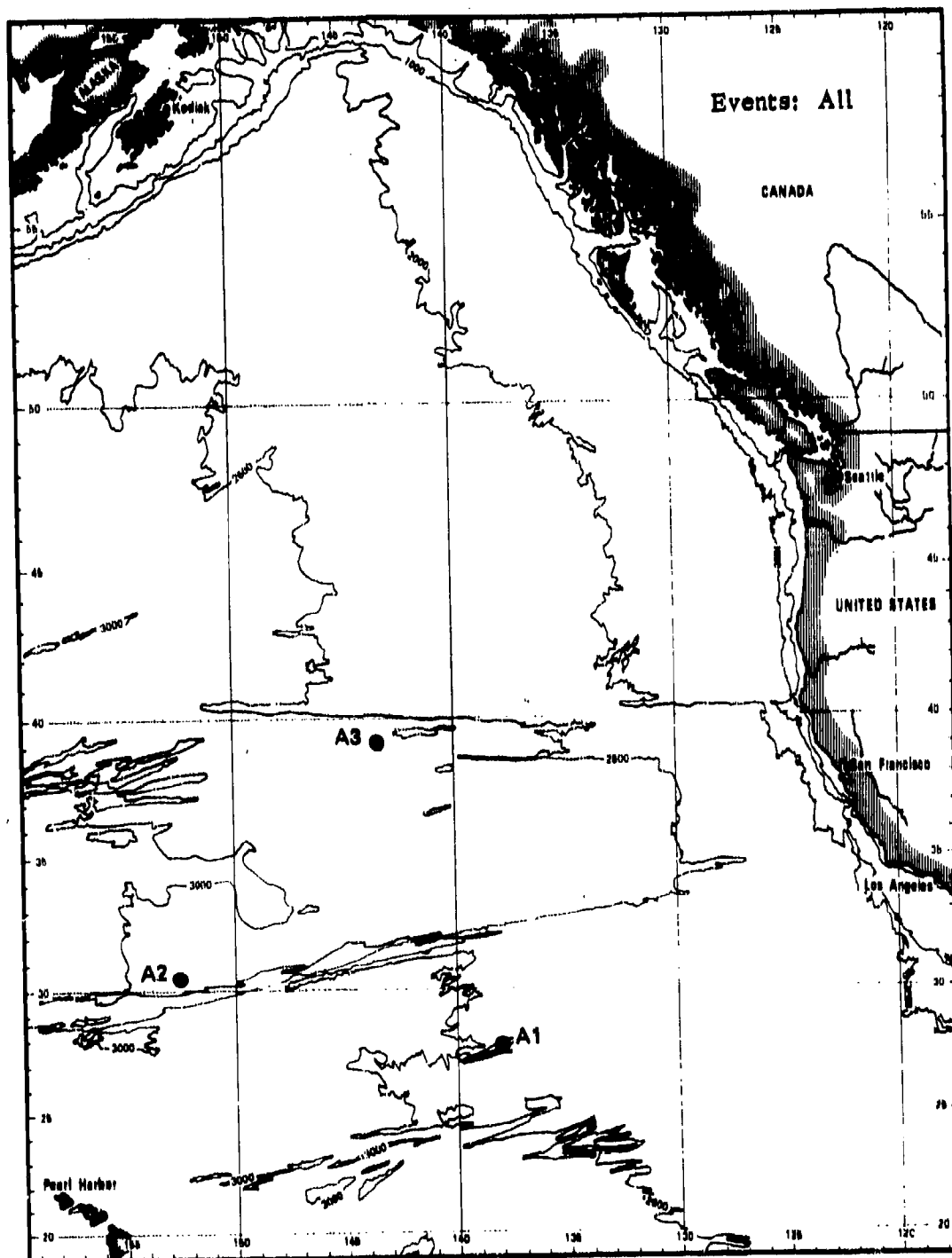


Figure 3. (C) Noise Floor Characteristics Experiment:
ACODAC Deployment Sites (U)

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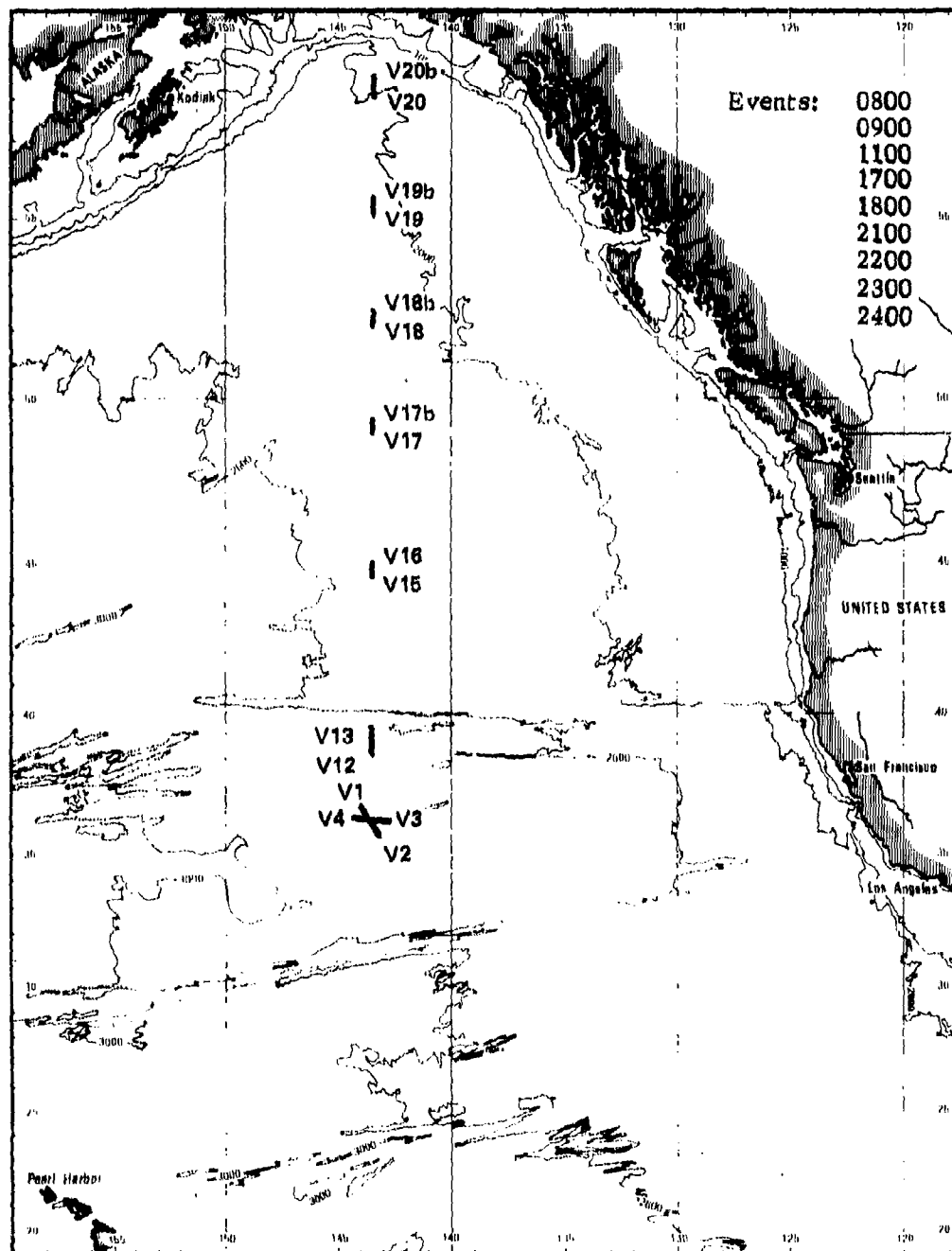


Figure 4. (C) Noise Floor Characteristics Experiment:
CW Source Tows for Simulating Distant Shipping (U)

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**Table B. (C) ACODAC Hydrophone Placements
(In Meters Above Bottom) (U)**

ACODAC Site	A1	A2	A3
Hydrophone No.			
1	4,470*	2,330*	2,500*
2	1,400	2,330	2,500
3	900	2,030	2,200
4	700	1,730	1,900
5	600	1,430	1,600
6	500	1,130	1,300
7	400	830	1,000
8	300	530	700
9	200	230	400
10	100	155	100
11	55	130	55
12	30	30	30
13	30*	30*	30*

*600-Hz bandpass hydrophone

with 14-channel tape recorders will be used to collect the acoustic data. One ACODAC will be deployed at Site A1, recovered, and redeployed at Site A2. The other ACODAC will be deployed at Site A3. The bottom depth, predicted noise floor depth, and predicted critical depth for the three sites are shown in Table C.

(C) Detailed wind speed data projected from the FNWC synoptic model will be obtained for the entire exercise period and extrapolated for the three ACODAC deployment sites. The wind predictions will be compared with data from the three Exercise ships and the recorded wind noise from the ACODACs.

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3.1.4 Analyses (U)

(C) The primary objective of the analysis is to determine the extent of the contributions of the bottom and local environmental on the formation of a noise floor. This determination is necessary for the evaluation of noise floor modeling. The analyses consist of the following:

- o The data from the two broadband hydrophones on each ACODAC will be processed and compared with the wind speed data to select two 1-hour samples typical of four different wind speed regimes from each ACODAC.
- o For each of these wind speed regimes and ACODAC sites, 1/3-octave broadband noise spectra will be reduced and compared to determine the ambient noise level and spectra versus sensor depth. The qualitative and quantitative differences in the noise versus depth versus wind speed at each of the sites will be established.

Table C. (U) ACODAC Site Characteristics (Meters) (U)

ACODAC Site	A1	A2	A3
Water Depth	4,700	5,300	5,555
Noise Floor Depth	4,540	5,000	4,400
Critical Depth	4,200	4,500	3,900

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3.2 ASEPS Evaluation; Inter-Array Coherent Processing (U)

(S) The primary objective of this experiment is to evaluate the ASEPS model for undersea surveillance application in the Exercise area. Data will be acquired that can be used to verify the propagation loss component of the model. The second objective is to compare propagation, S/N, effective array gain, and coherence between LAMBDA and a SOSUS array. Another objective is the demonstration of Coherent Multi-Array Processing (CMAP), with Doppler correction, between widely spaced mobile and fixed arrays. This objective is intended to verify the Doppler-Time Algorithm developed at NUC. The experiment has been designed to provide data for all three purposes.

3.2.1 Technical Objectives (U)

(S) The following are the prioritized objectives of this experiment:

- o Evaluation of the propagation loss model component of ASEPS. Propagation loss at several frequencies and several source depths will be compared with ASEPS model predictions.
- o Measurement and comparison of effective array gain and coherence. These measurements will be made for both signal and noise with the LAMBDA and bottomed arrays.
- o Verification of Doppler shift versus arrival time algorithm for a mobile sensor. Simultaneous Doppler-time shift measurements between a stationary array and the mobile LAMBDA array (approximately 3 knots) will be obtained. Simultaneous measurements of Doppler shift and arrival time from widely separated arrays with substantially different Doppler shifts from a single source will also be obtained.

3.2.2 Field Operations (U)

(S) Figures 5 and 6 show the operations related to the ASEPS evaluation. A series of short CW tows (V1 to V2, V3 to V4, V5 to V6, V7 to V8 to V9, and V10 to V11) will be made. These tows will be monitored by 1321, 1322, 1323, and 2411. Additional supporting data will be obtained by the ACODACS at

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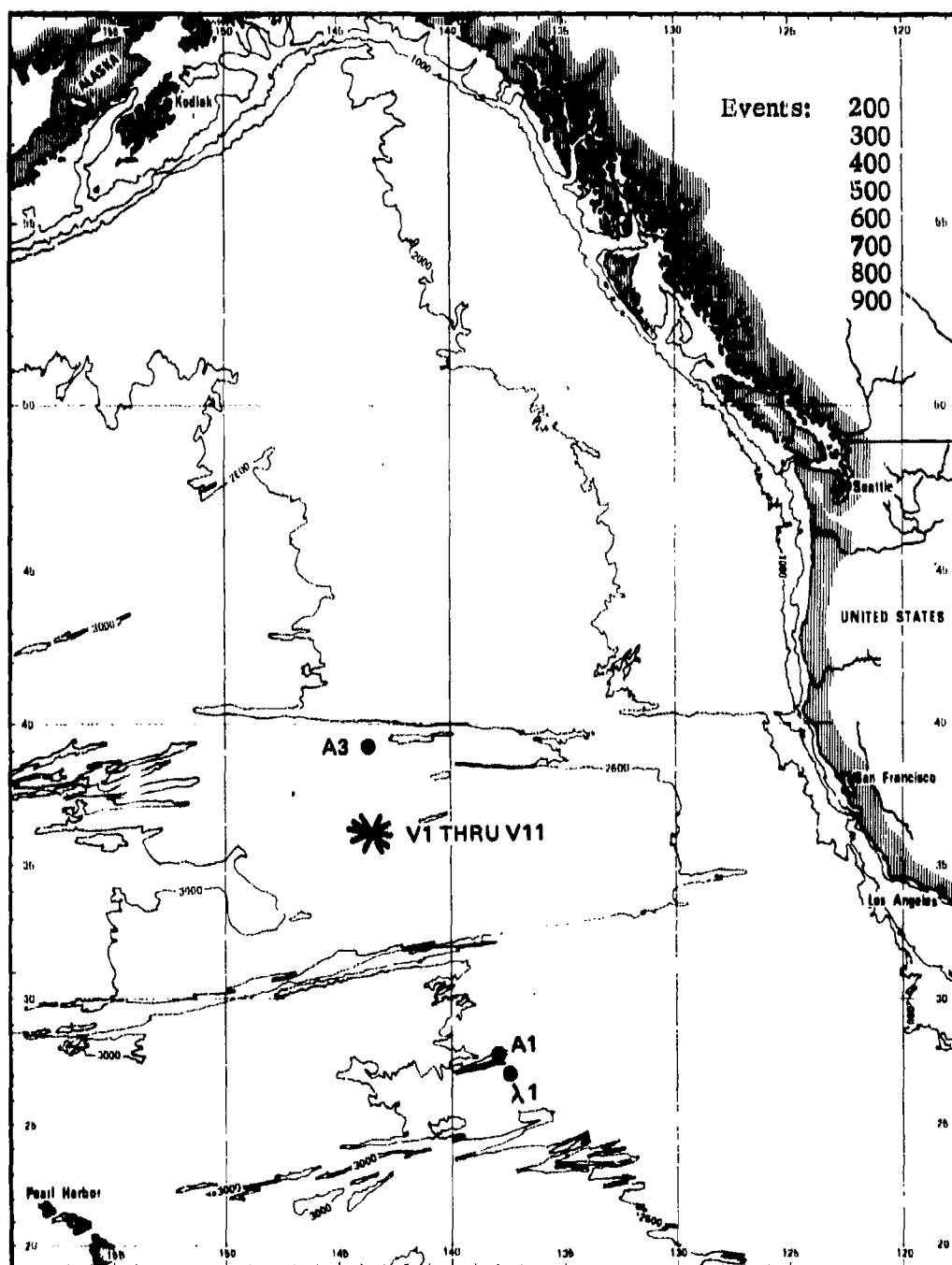


Figure 5. (C) ASEPS Evaluation Deployments: Part A (U)

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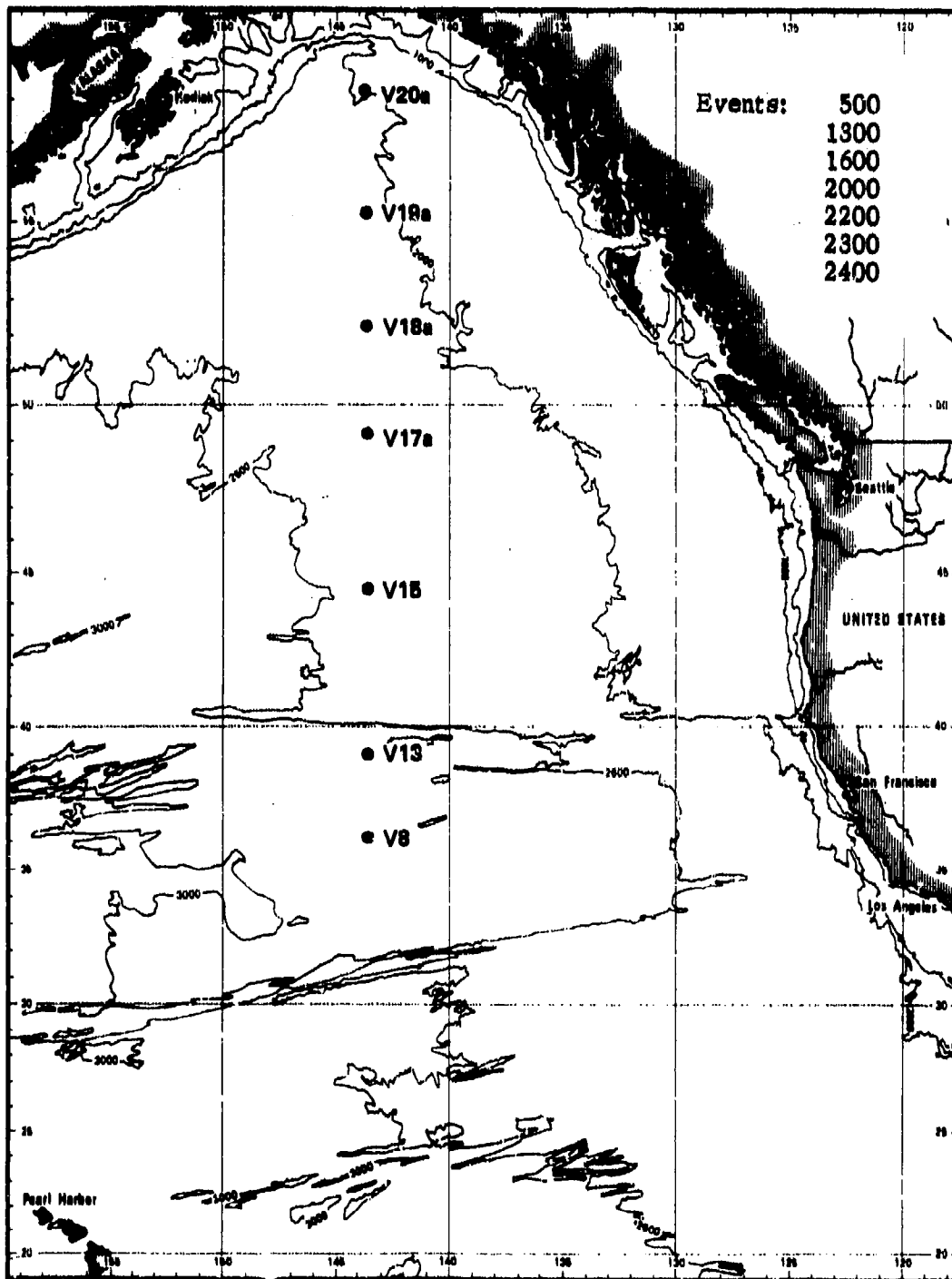


Figure 6. (C) ASEPS Evaluation Deployments: Part B (U)

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A1 and A3, and by LAMBDA at $\lambda 1$. Vibroseis will also execute depth cycles at V8, V13, V15, V17, V18, V19, and V20, and a transmission sequence at V13, V15, and V17. These depth and transmission cycles will be recorded on the NAVFAC station recorders at 1321, 1322, 1323, 1511, 2321, and 2411.

(S) Figure 7 shows the Exercise operations for the inter-array coherent processing experiment. It also includes the operations for SOSUS-LAMBDA comparisons. LAMBDA will occupy Site $\lambda 1$ during the 3-hour power cycle at V1 and the V1 to V2 tow. LAMBDA will then be towed at 3 knots from $\lambda 1$ to $\lambda 2$ during a CW source transmission at V3 and the V3 to V4 tow. LAMBDA will operate at Site λB during the V12 to V13 tow, and for the power and depth cycles at V13. These transmissions will also be recorded at 1321, 1322, and 1323.

3.2.3 Data Acquisition (U)

(S) The ASEPS experiment will obtain analog broadband recording of beams and hydrophones from 1321, 1322, 1323, and 2411. The recording for each of these arrays will be done with appropriate time codes. Sound speed profiles will be obtained at all Vibroseis sites. Bottom loss estimations for the area will be obtained from CHURCH ANCHOR and other archival data.

(S) LOFARGRAMS from each of the recorded beams will be retained for post-exercise evaluation. In addition, ACODAC data from deployment A1 will be used for comparison.

(S) The data for the inter-array coherent processing experiments will consist of simultaneous recordings aboard the SEISMIC EXPLORER and at 1321, 1322, and 1323. All 64 hydrophones of the LAMBDA array will be recorded, and hydrophones and beams from 1321, 1322, and 1323 will be recorded so that the beams may be coherently processed for Doppler shift and time. The data will be recorded using DAPAAN recorders.

(C) For the SOSUS-LAMBDA comparisons, LAMBDA will be deployed at a depth of 170 meters at $\lambda 1$ and $\lambda 2$ and the slow tow capability (approximately 0.5 knot) of SEISMIC EXPLORER will be utilized.

(S) The CW propagation loss will be processed onboard LAMBDA as received energy versus time. Ashore, the navigational data will be used to

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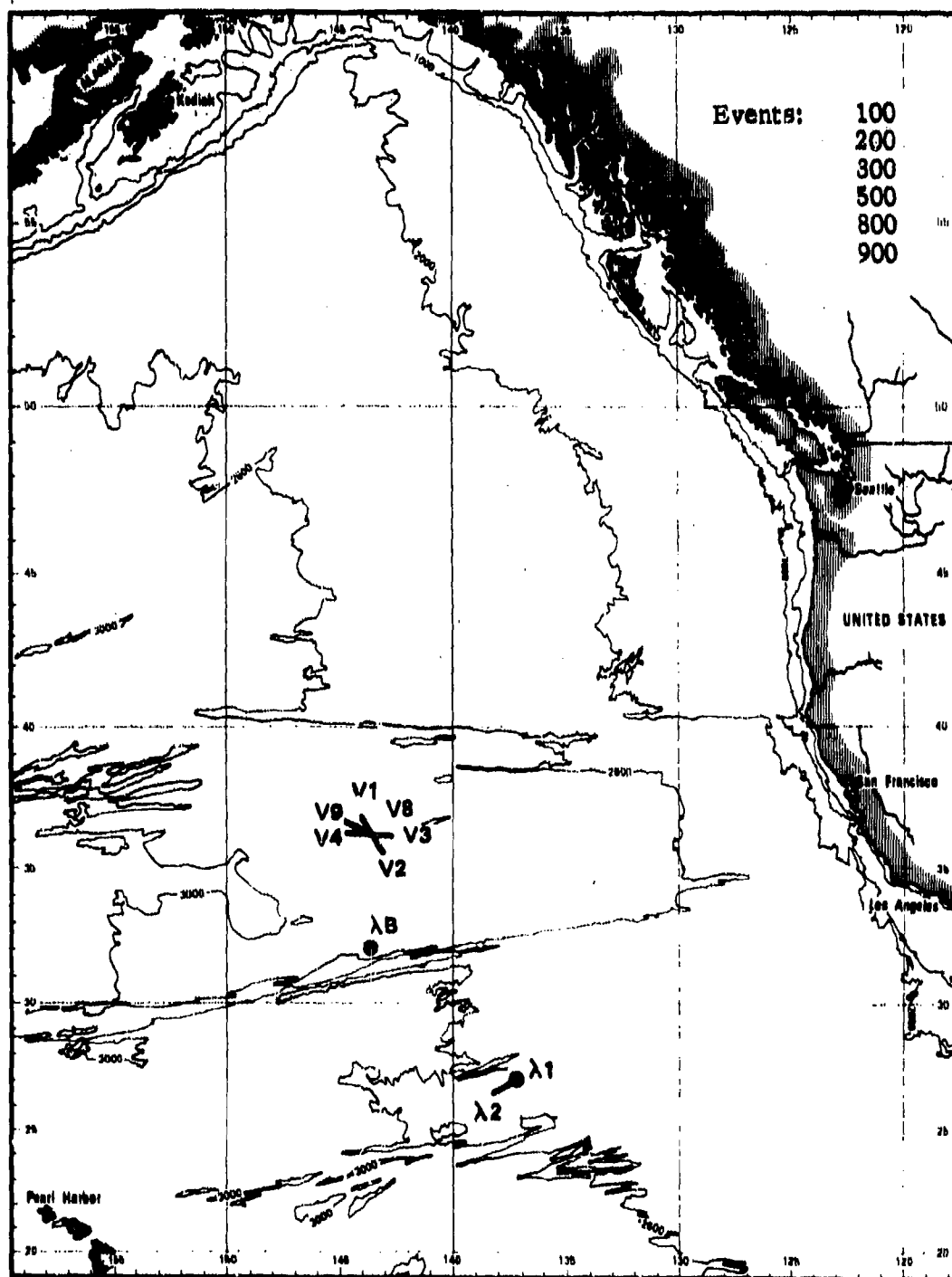


Figure 7. (C) Inter-Array Coherent Processing Deployments (U)

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substitute range for time. The data from a single hydrophone, the source-on beam, and the adjacent beams at the source frequencies and two adjacent frequencies (± 3 to 5 Hz) will be used to assess both the LAMBDA and SOSUS arrays. Coherence between two pairs of widely spaced hydrophones will be used with a mid-array hydrophone to sample the coherence across the aperture of the array.

3.2.4 Analyses (U)

(S) Propagation loss measurements will be made by 1321, 1322, 1323, 1511, 2321, 2411, ACODAC A1, and LAMBDA. These measurements will be compared with the appropriate ASEPS propagation loss predictions.

(S) For each of the transmission sequences and each of the source depths and frequencies, effective array signal gain and noise gain will be computed utilizing the main target beam versus the average of five individual hydrophones. The noise array gain will be determined at the same frequencies, narrow band, during the source-off periods. In addition, an array gain or beam-forming analysis will be accomplished by comparing the source-off beam with the two adjacent beams. Signal-to-noise ratio will be plotted and analyzed as a function of source strength at each frequency and each power cycle point.

(S) The ASEPS prediction model will be compared with the SOSUS beam data for the appropriate tows. The model will also be compared with the data received by ACODAC A1 on hydrophone #2 (1,400 meters above the bottom). It will also be compared with the beam and single hydrophone propagation data received by the LAMBDA array at Site A1.

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3.3 Horizontal Directionality of Ambient Noise; Towed Array Performance (U)

(C) One objective of this experiment is to test the horizontal noise directionality estimation technique developed at NUC. This experiment will be supported by a DELTA array deployment. The time stationarity of the noise field will be addressed by towing the LAMBDA array on three headings while maintaining the DELTA array on one heading.

(C) Two additional technical objectives are (1) to evaluate the towed array for long range detection capabilities, including the influence of the environment, i.e., an ocean frontal system, and (2) the effect of array deformation on propagation and coherence measurements. These objectives include determination of signal detection and coherence, S/N measurements, and noise statistics, with and/or without frontal interference, in a range-dependent manner.

(C) The objectives also include determination of the effect of array deformation on coherence by making simultaneous array deformation and coherence measurements.

3.3.1 Technical Objectives (U)

(C) The following is a prioritized list of specific technical objectives:

- o Measurement of horizontal noise directionality using LAMBDA and the DELTA array. LAMBDA will assume three to six separate headings concurrently with a DELTA deployment at a single heading, for evaluation of the NUC directionality estimating technique.
- o Measurement of narrow beam noise threshold and variability with LAMBDA. These measurements including temporal fluctuation measurements will be made to determine the ability of the towed array to make long range detections in the gaps between surface shipping interference.

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- o Comparison of beam noise measurements made with LAMBDA and DELTA. The DELTA array will be deployed near LAMBDA and the temporal fluctuations of beam noise measurements will be compared with the LAMBDA measurements.
- o Long range signal propagation and coherence. Measurements of signal propagation and coherence will be obtained at ranges up to 1,000 nm.
- o Determination of beam signal fluctuations, S/N, and noise statistics. CW transmissions will be made at ranges from 400 to 1,000 nm through oceanic frontal disturbances. Measurements will be made of coherence propagation statistics and beam noise during these periods.
- o Measurement of array deformation. Array deformation measurements will be made simultaneously with the long range coherence measurements.

3.3.2 Field Operations (U)

(C) Ambient noise horizontal directionality measurements will be made at λB as shown in Figure 8. The Vibrosels will act as a beacon for determining the headings of the LAMBDA array during these measurements. The DELTA array will be deployed in the vicinity of the LAMBDA array during one of the measurement periods and will provide a means for solving the ambiguities inherent in a linear array.

(C) A series of beam noise measurements will be made with the LAMBDA array at Sites λA and λB as shown in Figures 9 and 10. Fleet aircraft will provide ship surveillance. The WARF and SEA ECHO OTH radars will also provide shipping surveillance. During one of these measurement periods, the DELTA array will be deployed in close proximity to LAMBDA in an attempt to determine if the beam noise threshold levels observed on LAMBDA represent an environmental limitation or a LAMBDA-system limitation.

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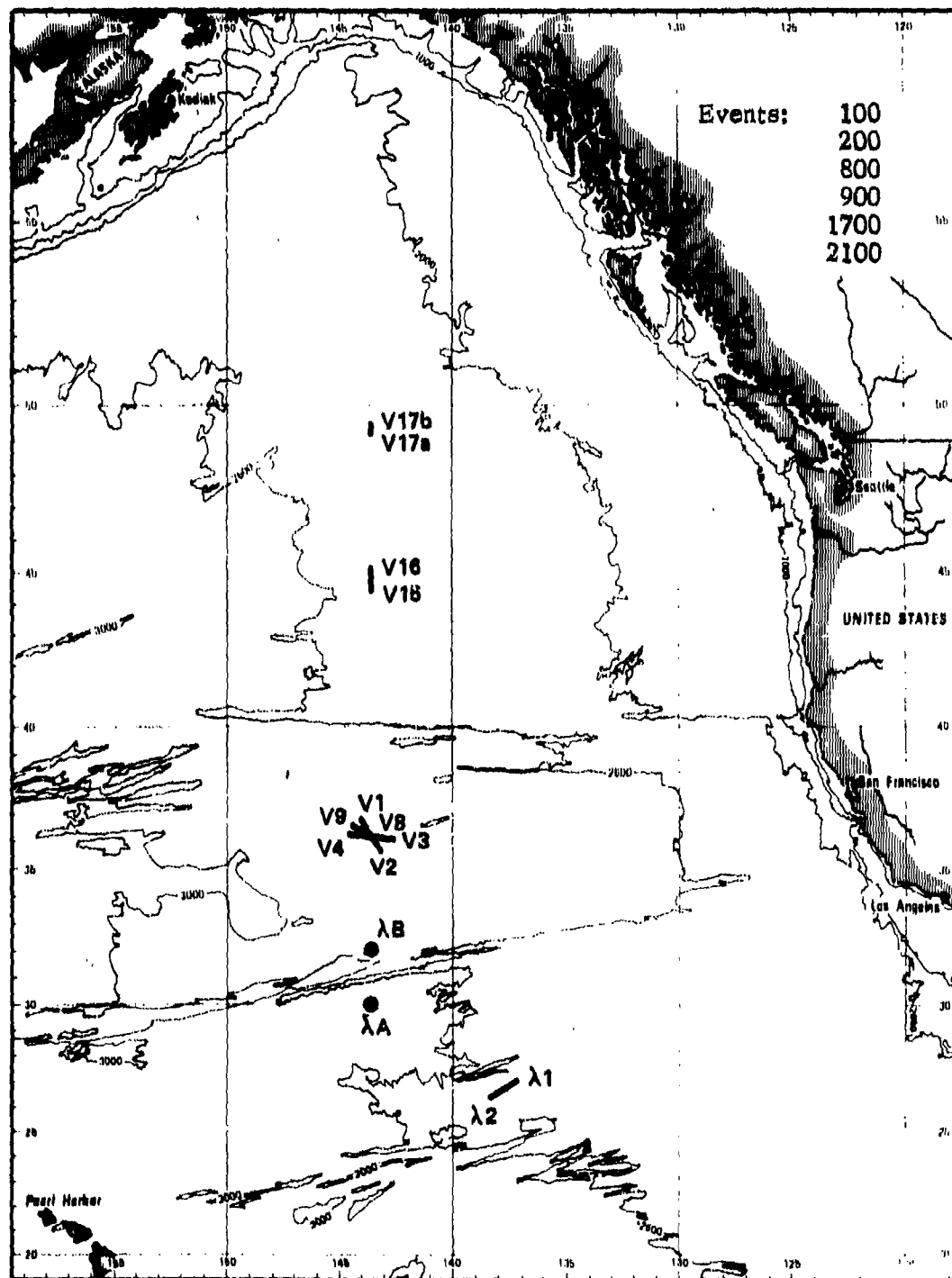


Figure 8. (C) Ambient Noise Horizontal Directionality Measurements (U)

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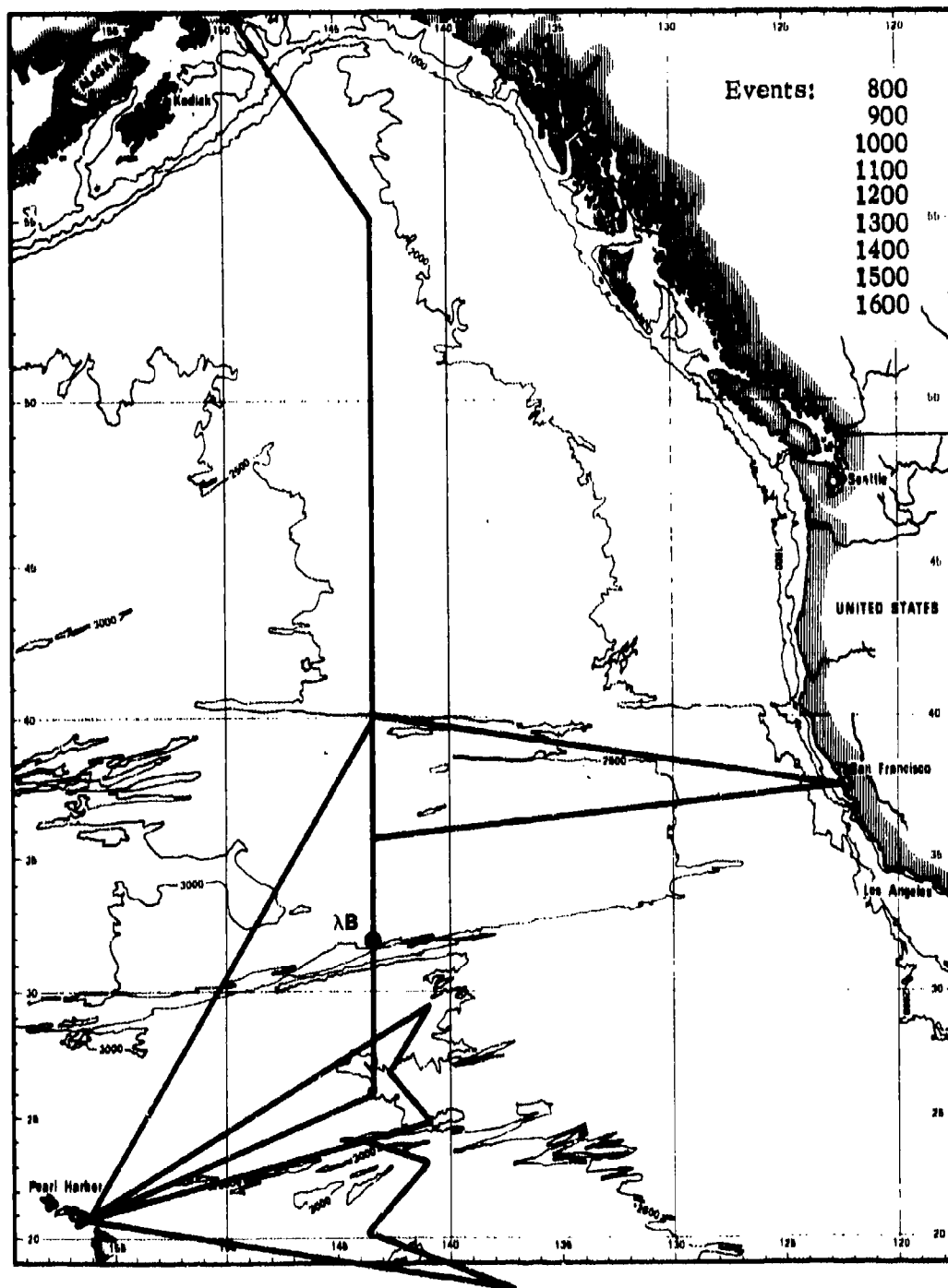


Figure 10. (C) Towed Array Performance: Beam Noise Measurements at AB and Aircraft Tracks for Shipping Surveillance (U)

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(C) Signal propagation and coherence measurements will be made for transmission paths ranging from 300 to 1,000 nm as shown in Figure 11. The Vibroseis will be towed while transmitting CW sequences.

(C) MOANA WAVE will operate an auxiliary source (HX-231-F) close to LAMBDA for measuring the array deformation. This source will transmit short pulses with a 1-minute pulse repetition rate. This sequence will allow for the separation of direct, surface-reflected, and bottom-bounce paths:

3.3.3 Data Acquisition (U)

(S) During the noise directionality measurements, the DELTA array will be deployed during the daylight portions of the LAMBDA measurement periods. The Vibroseis will transmit as a beacon. The LAMBDA array (LF and MF sections), utilizing the SD 301 data processor, will produce the spectra of the broadside beam and a single hydrophone. The onboard digital recorder will record the 128 beams or 64 hydrophones from the processor.

(S) For the beam noise threshold, the MF and HF sections of the LAMBDA array will be used. The updated LAMBDA processor will be used on line and during transits to process noise intensity versus aperture and noise intensity versus azimuth for five beams (near broadside) at three frequencies.

(S) For the signal propagation and coherence measurements, the 64-channel analog recorder will be on line. The SD 301 spectrum analyzers and LAMBDA processor will be used on line to provide S/N and noise versus aperture and azimuth at three pairs of frequencies associated with the array segments. During these operations, the array will be operated in the LF mode. The array switching will be coordinated with the source frequencies appropriate to the three arrays. The frequencies will be each of the two simultaneous propagation frequencies, one frequency 3 to 5 Hz below and one frequency 3 to 5 Hz above each of the transmission frequencies. The beams will be the source-on beam and adjacent beams. This procedure will allow for onboard S/N, beam quality, and noise measurements during CW-off cycles.

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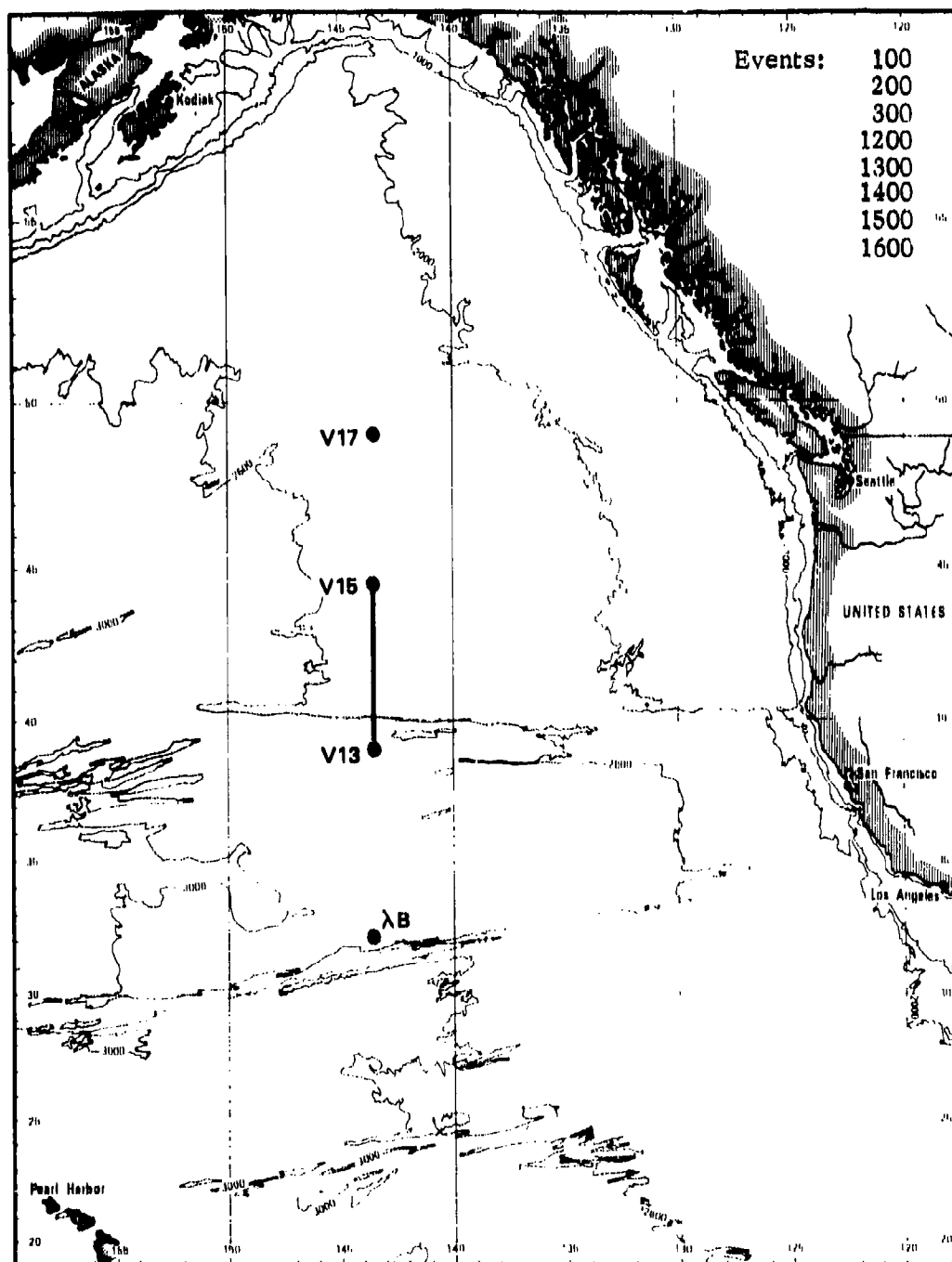


Figure 11. (C) Towed Array Performance: Propagation Loss and Coherence Measurements (U)

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3.3.4 Analysis (U)

(C) The LAMBDA hydrophone data will be analyzed ashore for coherence versus aperture across the LF array. This analysis should provide a comparison of coherence versus aperture with and without frontal interference. The DELTA data will be processed onboard with the LAMBDA processor.

(C) The S/N and noise portions of the experiments in all three array modes should be derivable from the onboard processing.

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3.4 Shipping Surveillance (U)

(C) The WARF and SEA ECHO, over-the-horizon radars, will be used to provide surveillance of surface shipping in limited portions of the Exercise area for 5 days each. A VXN-8 P-3A will conduct shipping surveillance in the WARF area on 3 days and in the SEA ECHO area on 3 days to verify the ship counts.

3.4.1 Technical Objectives (U)

(C) The following technical objectives of the shipping surveillance are listed in order of priority:

- o Determine the nearby shipping distribution concurrent with LAMBDA horizontal directionality measurements at λA and concurrent with LAMBDA and DELTA horizontal directionality measurements at λB .
- o Determine ships on LAMBDA beams during beam noise threshold measurements. The establishment of the number of ships on each LAMBDA beam during the beam noise threshold measurements will allow determination of the beam noise threshold levels in the absence of surface ships.
- o Evaluate the OTH radar measurements of shipping distributions. The simultaneous aircraft surveillance of the OTH radar surveillance areas will allow an evaluation of the OTH coverage.

3.4.2 Field Operations (U)

(C) The WARF radar will operate during daylight hours for 5 days. WARF will have three surveillance areas that will be changed each day to correspond with the areas of acoustic measurements. The SEA ECHO radar will also operate during daylight hours for 5 days. SEA ECHO will have two surveillance areas that will be changed each day to correspond with the acoustic measurement areas. The surveillance areas are shown in Figure 12, and their approximate positions are given as follows:

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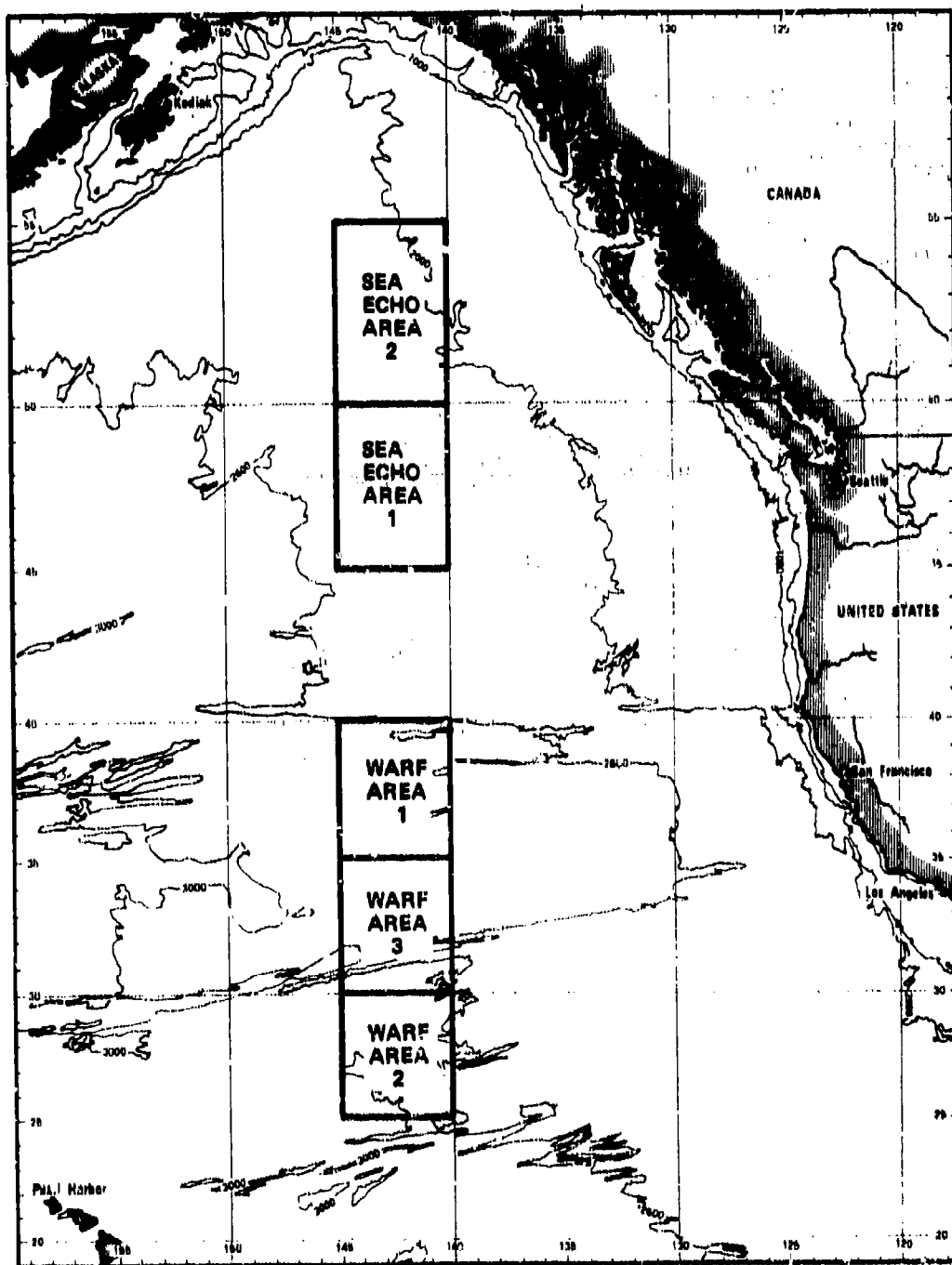


Figure 12. (C) OTH Radar Coverage Areas (U)

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(C) The WARF surveillance areas are as follows:

WARF Area 1: 35° - 40°N/140° - 145°W (approximate)

WARF Area 2: 25° - 30°N/140° - 145°W (approximate)

WARF Area 3: 30° - 35°N/140° - 145°W (approximate)

These areas will be scanned according to the following schedule:

WARF Area 1: 10 September 1975

WARF Area 2: 13 and 14 September 1975

WARF Area 3: 11 and 12 September 1975

(C) The SEA ECHO surveillance areas are as follows:

SEA ECHO Area 1: 45° - 50°N/140° - 145°W (approximate)

SEA ECHO Area 2: 50° - 55°N/140° - 145°W (approximate)

These areas will be scanned according to the following schedule:

SEA ECHO Area 1: 22 and 23 September 1975

SEA ECHO Area 2: 20, 21, and 24 September 1975

3.4.3 Data Acquisition (U)

(C) Stanford Research Institute (SRI) will process the WARF radar data and deliver tracks of the detected ships. These data will include estimated ship courses, speeds, and sizes. NRL will process the SEA ECHO radar data and will deliver ship populations for each resolution cell within the surveillance area. A chart will be provided that identifies the geodesy of each measurement cell. The aircraft surveillance data will yield contact plots for the surveillance area.

3.4.4 Analysis (U)

(C) The OTH radar data will be compared with the aircraft surveillance and ship report data. The aircraft surveillance data will be used as a basis for determining the contacts missed by the OTH radar and the false alarm rate of the OTH radar.

(C) The WARF radar and VXN-8 surveillance schedules were selected so that coverage of λA and λB will be concurrent with LAMBDA and joint LAMBDA -

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DELTA operations at these sites. This concurrence will aid the interpretation of ambiguous and unambiguous noise roses for λA and λB .

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3.5 Environmental Support (U)

(U) Throughout the three acoustic experiments, there are requirements for environmental data as follows:

- o Determination of wind speed as a function of time at three ACODAC sites
- o Measurements of sound speed profiles
- o Determination of reconciled ship tracks for range data

3.5.1 Wind Speed Data (U)

(U) Wind speed data from all three ships will be acquired as a function of time throughout the experiments. The data from these sources will be compared with the FNWC synoptic model. These data will be used to select specific noise floor data periods and to parameterize the noise floor data with wind speed.

3.5.2 Sound Speed Profiles (U)

(C) The sound speed data will be derived from STD/SV casts at locations shown in Figure 13 and from XBT and AXBT deployments (Figure 14). The sound speed data will provide inputs to ASEPS for prediction evaluation. Complete sound speed profiles along the propagation track will be obtained for modeling support to the SOSUS-LAMBDA propagation comparison.

3.5.3 Reconciled Ship Tracks (U)

(U) Source-to-receiver ranges are required for all source-receiver combinations during the acoustic experiments.

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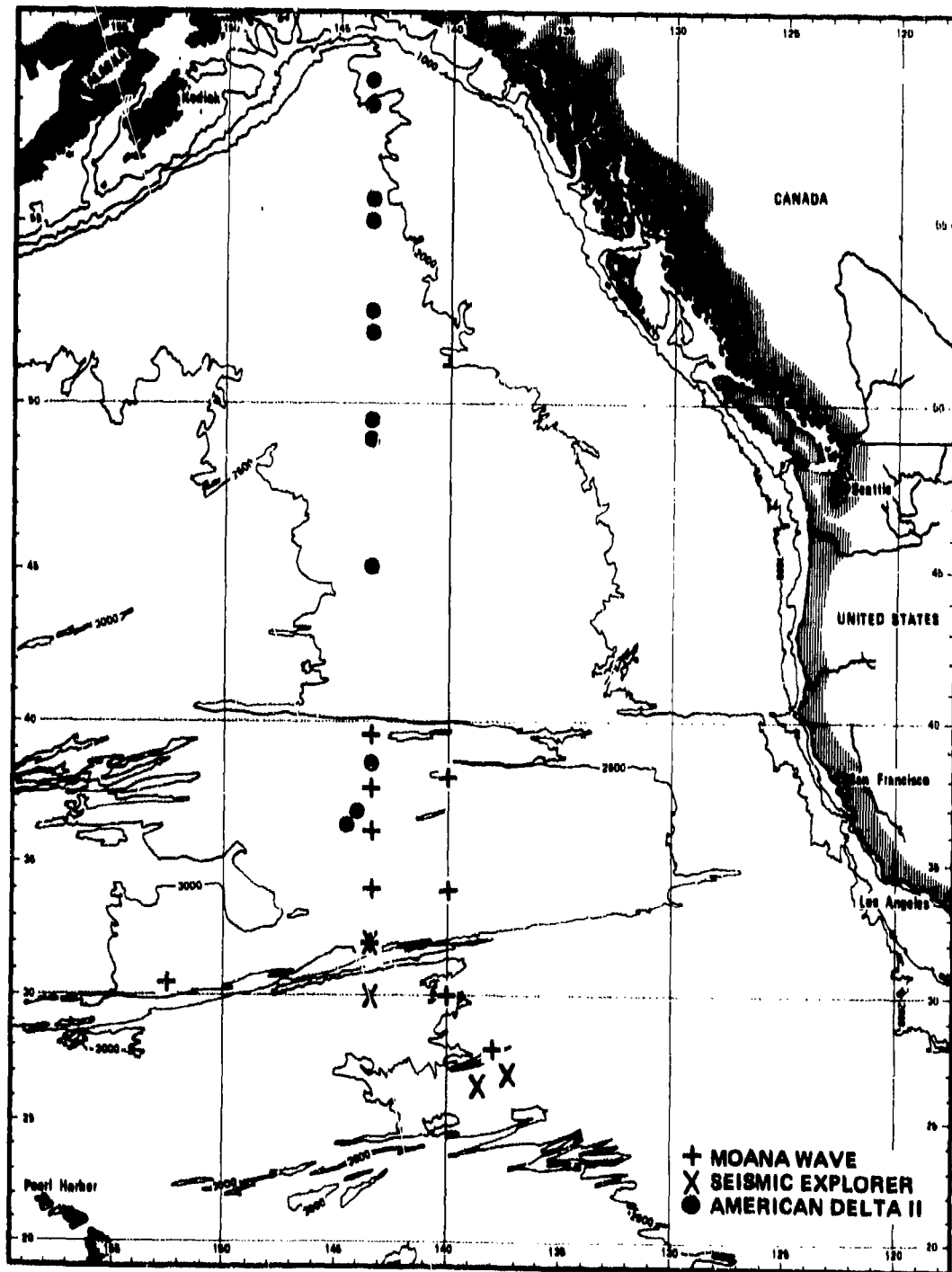


Figure 13. (C) STD/SV Stations (U)

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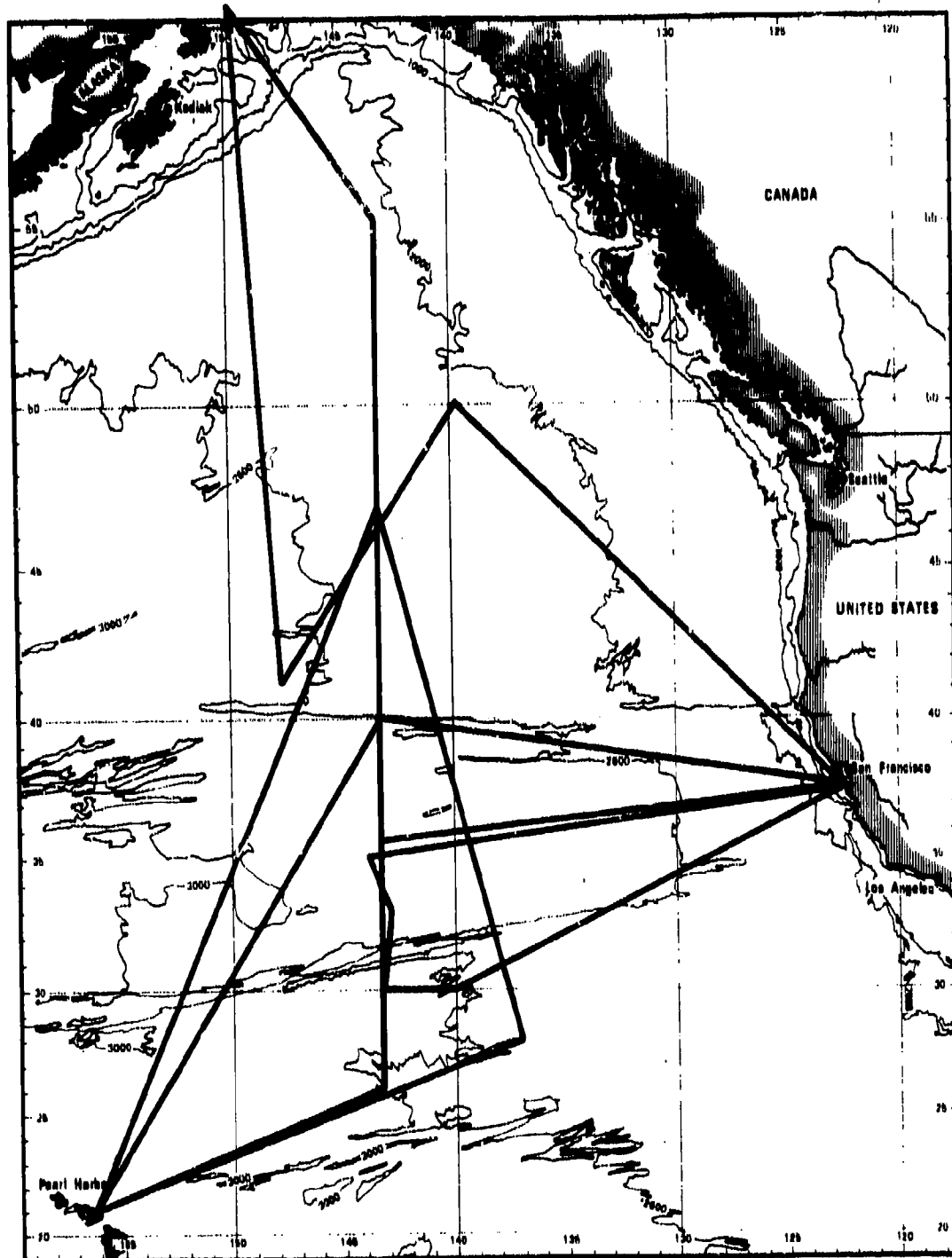


Figure 14. (C) Aircraft Tracks for AXBT Data (U)

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4. MANAGEMENT AND REPORTS (U)

(C) The management organization for this Exercise is shown in Figure 15. This program is under the general technical direction of the Manager, LRAPP, Dr. Roy D. Gaul, and the Scientific Officer, Mr. Edward L. Smith. The overall responsibility for the conduct of the Exercise operations will be vested in the Officer Conducting the Exercise (OCE), COMTHIRDFLT, who will also serve as the Officer in Tactical Command (OTC), CTG 30.5. COMTHIRDFLT has designated CDR George E. Lawniczak, Jr., as Project Officer for the Exercise.

(U) Responsibility for the technical organization, planning, and execution of the Exercise is vested in the Technical Director (TD), Mr. Sidney Kulek (Xonics), who is supported by senior members of the Xonics staff. An ad hoc Technical Advisory Group (TAG) was established to advise the Technical Director on technical aspects of the program. The TAG reviewed documents with the TD to verify technical adequacy, utilization of assets, integration with other experiments, and planning for interpretive analysis of data. Dr. Scott C. Daubin of the University of Miami was appointed Chairman of the TAG. The other members of TAG are Mr. Roy T. Brown (TRW), Dr. Robert R. Gardner (PME-124/TA), Dr. John S. Hanna (AESD), and Mr. John A. Hess (URC).

(U) During the Exercise, the TD will report to the OTC for tactical control. The TD and the OTC will be located at EXCON (COMTHIRDFLT Headquarters) during the Exercise. Principal Investigators (PI's) are responsible for performance of the technical experiments (Table D). Unit Investigators (UI's) aboard each platform (Table E) are responsible for execution of experiments in accordance with the Exercise Plan.

(C) The data acquired during the Exercise will be analyzed, and the results presented in a series of reports. Interim Technical Notes will be prepared by the individual Unit Investigators and Principal Investigators during and immediately following the Exercise. These Technical Notes will describe



Figure 15. (C) CHURCH OPAL Technical Management Structure (U)

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the extent and estimated quality of the data collected and significant results obtained to date.

(C) A Synopsis Report will be published on 1 January 1976 by the Technical Director from contributions from the Unit and Principal Investigators. This report will include a comprehensive assessment of exercise operations, a complete data inventory, and a discussion of problem areas. It will assess data quality, report preliminary results, and present a revised data analysis plan based on the data actually collected and the initial conclusions.

(C) Technical Reports will be issued by participating organizations. They will cover high interest results of immediate application and a detailed analysis of experiments under their cognizance. Table F indicates the schedule for the Technical Reports.

(C) The Environmental Acoustic Summary Report will be the primary output of the acoustic measurements. It will provide a comprehensive summary of the environmental acoustic characteristics of the Exercise area. It will be prepared by 1 October 1976.

(C) The Technical Director is responsible for the coordination, preparation, and publication of all reports.

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Table D. (C) Principal Investigators (U)

Study	Principal Investigators	Organization
Noise Floor Characteristics	A. F. Wittenborn	Tracor
ASEPS Evaluation	R. J. Hecht	USI
Inter-Array Coherent Processing	R. R. Kolesar	NUC
SOSUS-LAMBDA Propagation Loss Comparison	R. R. Kolesar	NUC
Horizontal Directionality of Ambient Noise	R. A. Wagstaff	NUC
Towed Array Performance	S. W. Marshall	NRL
Environmental Measurements	K. W. Lackie	NAVOCEANO
Shipping Surveillance	L. P. Solomon	PSI

Table E. (C) Unit Investigators (U)

Platform	Unit Investigators	Organization
SEISMIC EXPLORER with LAMBDA	C. L. Morningstar	NUC
AMERICAN DELTA II with Vibroseis	W. Clark	Xonics
MOANA WAVE with ACODAC	T. M. Mitchell	TI
VXN-8 Aircraft	K. W. Lackie	NAVOCEANO
Shore Station A		NUC
Shore Station B		NAVOCEANO

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Table F. (C) Summary of Technical Reports (U)

1.	Noise Floor Report Wind Speed Parameterization Omndirectional Intensities Spectral Characteristics Time Fluctuations Vertical Noise Coherence	1 Mar 1976 Tracor
2.	ASEPS Evaluation Report Array Signal Gain--Measured Noise Array Gain--Measured Beam Quality Propagation Loss Comparison of PL to Model	1 Mar 1976 USI/AESD
3.	Inter-Array Coherent Processing Report Experimental Synopsis Data Base Quality Feasibility for Mobile Sensor Propagation Loss	1 Feb 1976 NUC
4.	Towed Array Performance Report Signal Propagation Statistics Noise and Narrow Beam Noise S/N and Detection Capabilities Coherence and Fluctuations Beam Quality Effects of Water Mass on Array Performance	1 Mar 1976 NRL
5.	Array Deformation Report Analysis of Hydrophone Position Data Feasibility of Measurement Dynamic Modes of Array Feasibility of Application of Array Dynamics to Data Acquisition	1 May 1976 NRL
6.	SOSUS/LAMBDA Comparison	1 May 1976 NUC
7.	Environmental Measurements Report	1 Mar 1976 NAVOCEANO
8.	Ship Tracks Report (Informal)	1 Dec 1975 NAVOCEANO
9.	Ambient Noise Horizontal Directionality Report	1 Mar 1976 NUC
10.	Shipping Surveillance Report	1 Dec 1975 PSI

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APPENDIX A

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SHIP OPERATIONS (U)

(U) This appendix provides a summary of the ship operations for the CHURCH OPAL Exercise. Specific details are contained in the CHURCH OPAL Exercise Plan (U), August 1975 (Secret).

1. M/V AMERICAN DELTA II (U)

(C) M/V AMERICAN DELTA II will tow the Vibroseis, record bathymetry, and make T-5 and T-7 XBT measurements.

(C) AMERICAN DELTA II track is shown in Figures A-1 and A-2, and her detailed event schedule is given in the CHURCH OPAL Exercise Plan. AMERICAN DELTA II will depart the San Diego Sea Buoy on 310500Z August. She will transit to V1 and deploy the Vibroseis sources. Vibroseis will make a transmission at V1, a tow from V1 to V2, a stationary transmission at V3, a tow from V3 to V4, a tow from V5 to V6, a tow from V7 to V8, a depth cycle at V8, a tow from V8 to V9, a tow from V10 to V11, a tow from V1 to V2, a tow from V2 to V3, a tow from V3 to V4, a tow from V12 to V13, a stationary transmission at V13, a depth cycle at V13, a tow from V13 to V14 to V15, a stationary transmission at V15, a depth cycle at V15, a tow from V15 to V16, a tow from V17 to V17A, a stationary transmission at V17A, a depth cycle at V17A, a tow from V17A to V17B, a tow from V18 to V18A, a depth cycle at V18A, a tow from V18A to V18B, a tow from V19 to V19A, a depth cycle at V19A, a tow from V19A to V19B, a tow from V20 to V20A, a depth cycle at V20A, and a tow from V20A to V20B. She will then transit to Kodiak, Alaska.

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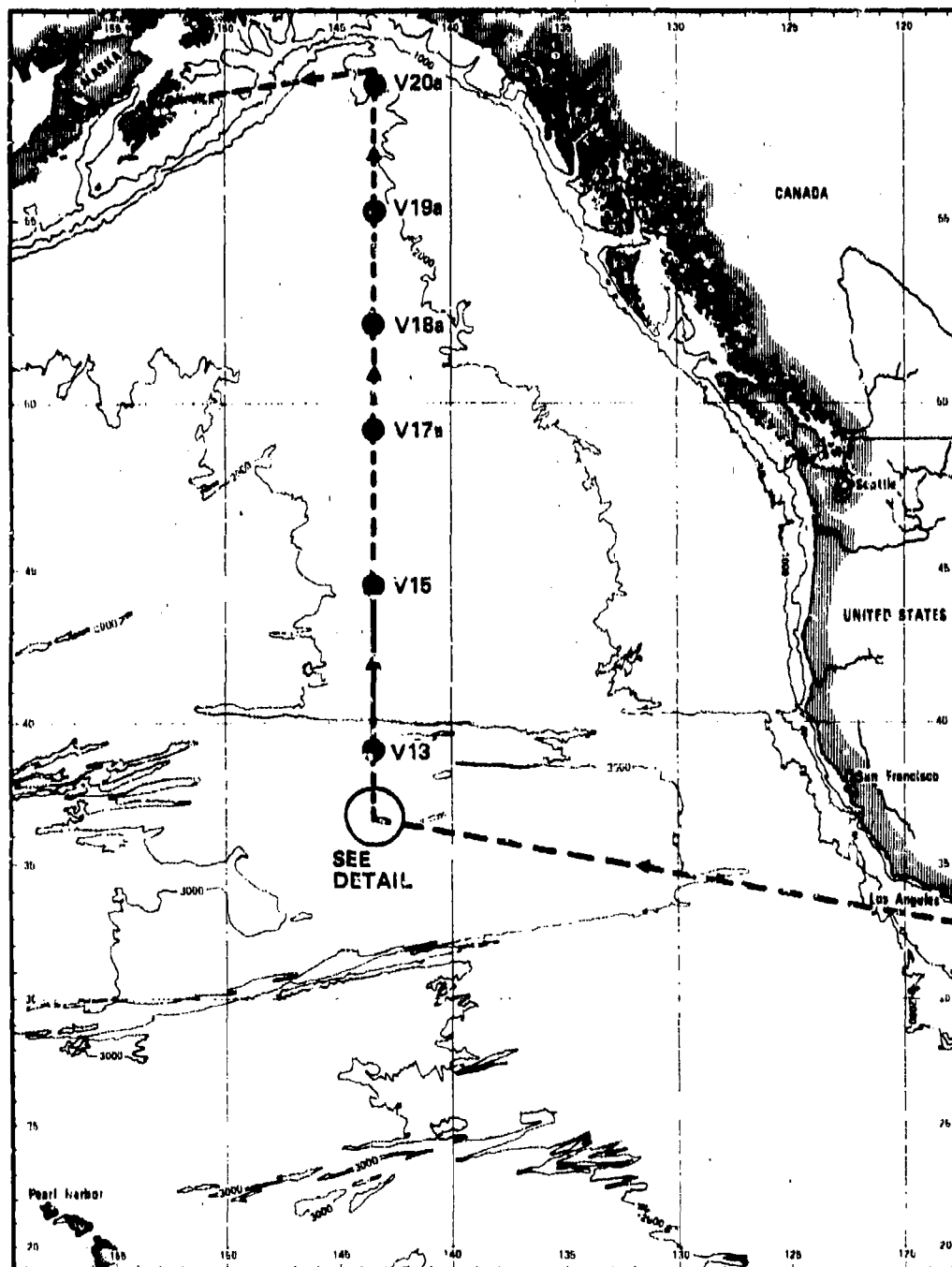
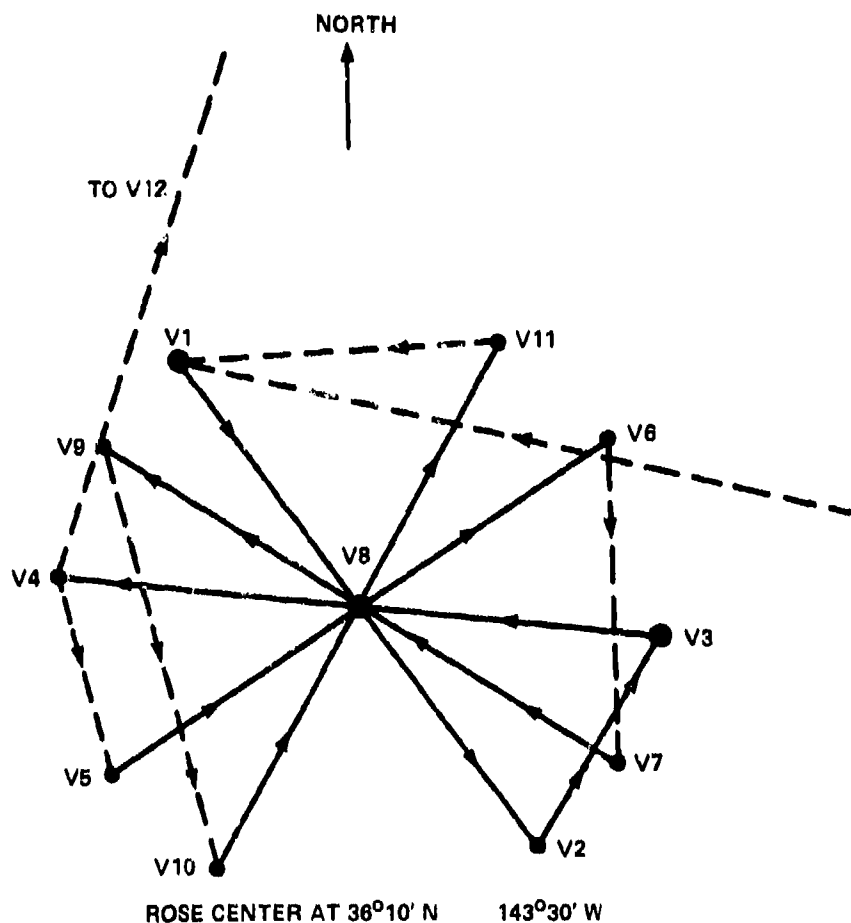


Figure A-1 (C) M/V AMERICAN DELTA II Track (U)

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	FROM			TO		ON
	<u>LAT</u>	<u>LONG</u>		<u>LAT</u>	<u>LONG</u>	<u>HEADING</u>
	<u>N</u>	<u>W</u>		<u>N</u>	<u>W</u>	<u>°T</u>
V1:	36°42.7'	143°58.7'	V2:	35°37.3'	143°01.7'	145°
V2:	35°37.3'	143°01.7'	V3:	36°05.3'	142°40.9'	030°
V3:	36°05.3'	142°40.9'	V4:	36°14.7'	144°19.2'	277°
V5:	35°47.7'	144°10.9'	V6:	36°32.3'	142°40.9'	056°
V7:	35°48.2'	142°48.6'	V8:	36°10'	143°30'	303°
V8:	36°10'	143°30'	V9:	36°31.8'	144°11.7'	303°
V10:	35°35.2'	143°54.4'	V11:	36°44.8'	143°05.3'	030°

Figure A-2 (C) M/V AMERICAN DELTA II Track Detail (U)

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2. M/V SEISMIC EXPLORER (U)

(C) M/V SEISMIC EXPLORER will tow LAMBDA, record bathymetry, and make STD/SV and T-5 and T-7 XBT measurements during the Exercise.

(C) SEISMIC EXPLORER track is shown in Figure A-3, and her detailed event schedule is given in the CHURCH OPAL Exercise Plan. SEISMIC EXPLORER will depart the San Diego Sea Buoy on 010200Z September. She will transit to $\lambda 1$ and deploy LAMBDA. LAMBDA will make measurements in a slow-tow mode (0.5 knot) at $\lambda 1$ and then in the tow mode (3 knots) on a tow from $\lambda 1$ to $\lambda 2$. SEISMIC EXPLORER will then recover LAMBDA and transit to λA where she will deploy LAMBDA, and LAMBDA will make measurements in the slow-tow mode. SEISMIC EXPLORER will recover LAMBDA and transit from λA to λB . At λB , LAMBDA will make measurements in the slow-tow mode for 13 days. SEISMIC EXPLORER will then recover LAMBDA and transit to Honolulu.

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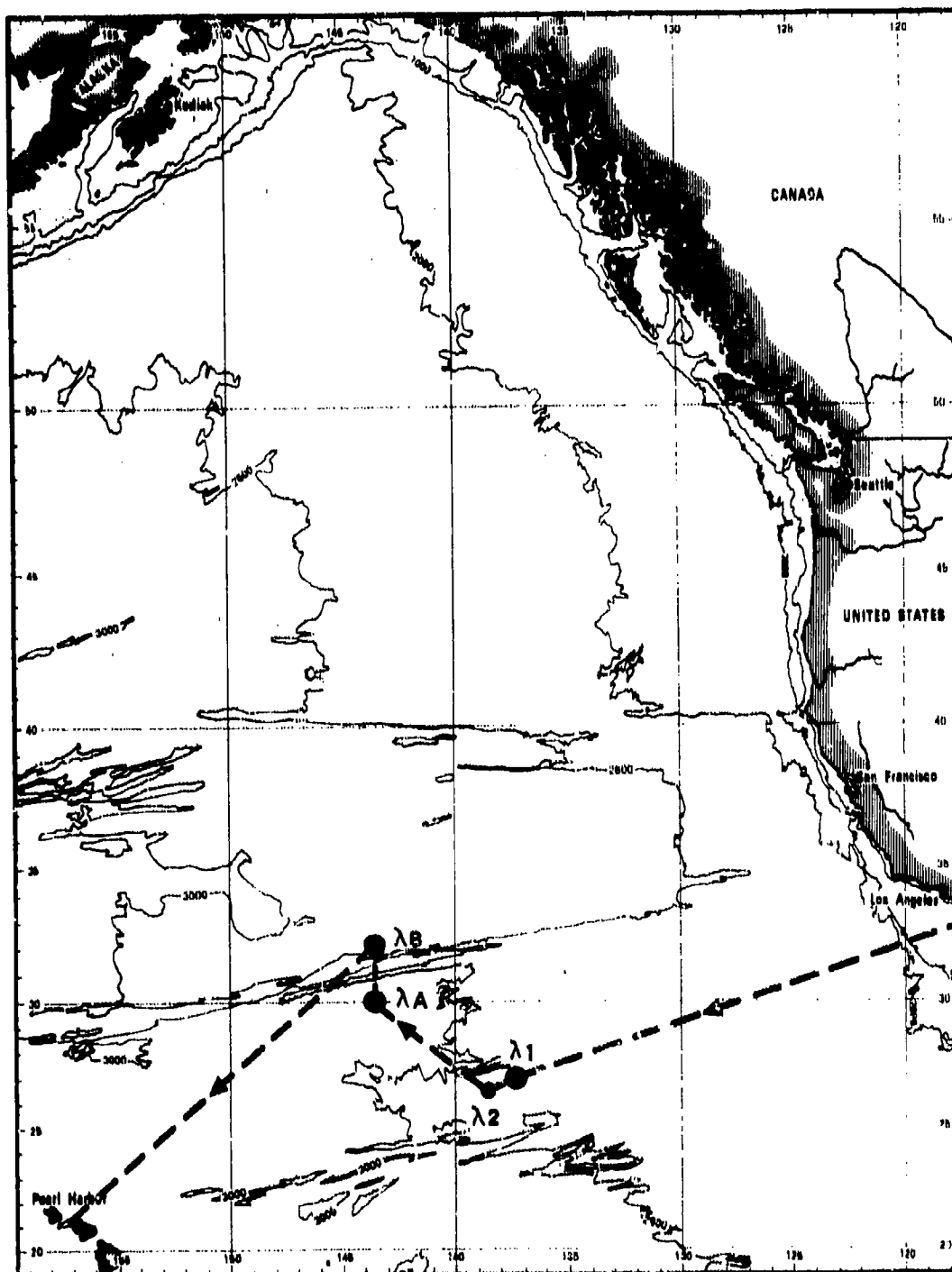


Figure A-3. (C) M/V SEISMIC EXPLORER Track (U)

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3. R/V MOANA WAVE (U)

(C) R/V MOANA WAVE will deploy ACODACs, the HX source, and the DELTA array. She will also record bathymetry and make STD/SV and T-5 and T-7 XBT measurements.

(C) MOANA WAVE track is shown in Figure A-4, and her detailed event schedule is shown in the CHURCH OPAL Exercise Plan. MOANA WAVE will depart the San Diego Sea Buoy on 311100Z August. She will transit to A1 and deploy an ACODAC. She will then transit to 30°N 140°W and take an STD/SV. She will continue the transit north along 140°W taking two more STD/SVs. From 38°N 140°W, she will transit to A3 where she will deploy an ACODAC. She will then transit to λB taking STD/SVs enroute. At λB, she will make two deployments of DELTA in conjunction with LAMBDA and operate the HX source for array deformation measurements. MOANA WAVE will then transit to A1, recover the ACODAC, transit to A2, and deploy the ACODAC. She will transit to λB where she will make two deployments of DELTA and operate the HX source for array deformation measurements. The MOANA WAVE will make environmental measurements, including XBTs, throughout the Exercise. At the conclusion of the HX source operations, MOANA WAVE will transit to Honolulu. After a short stay in Honolulu, she will recover the ACODACs at A2 and A3 and transit to San Diego (Figure A-5).

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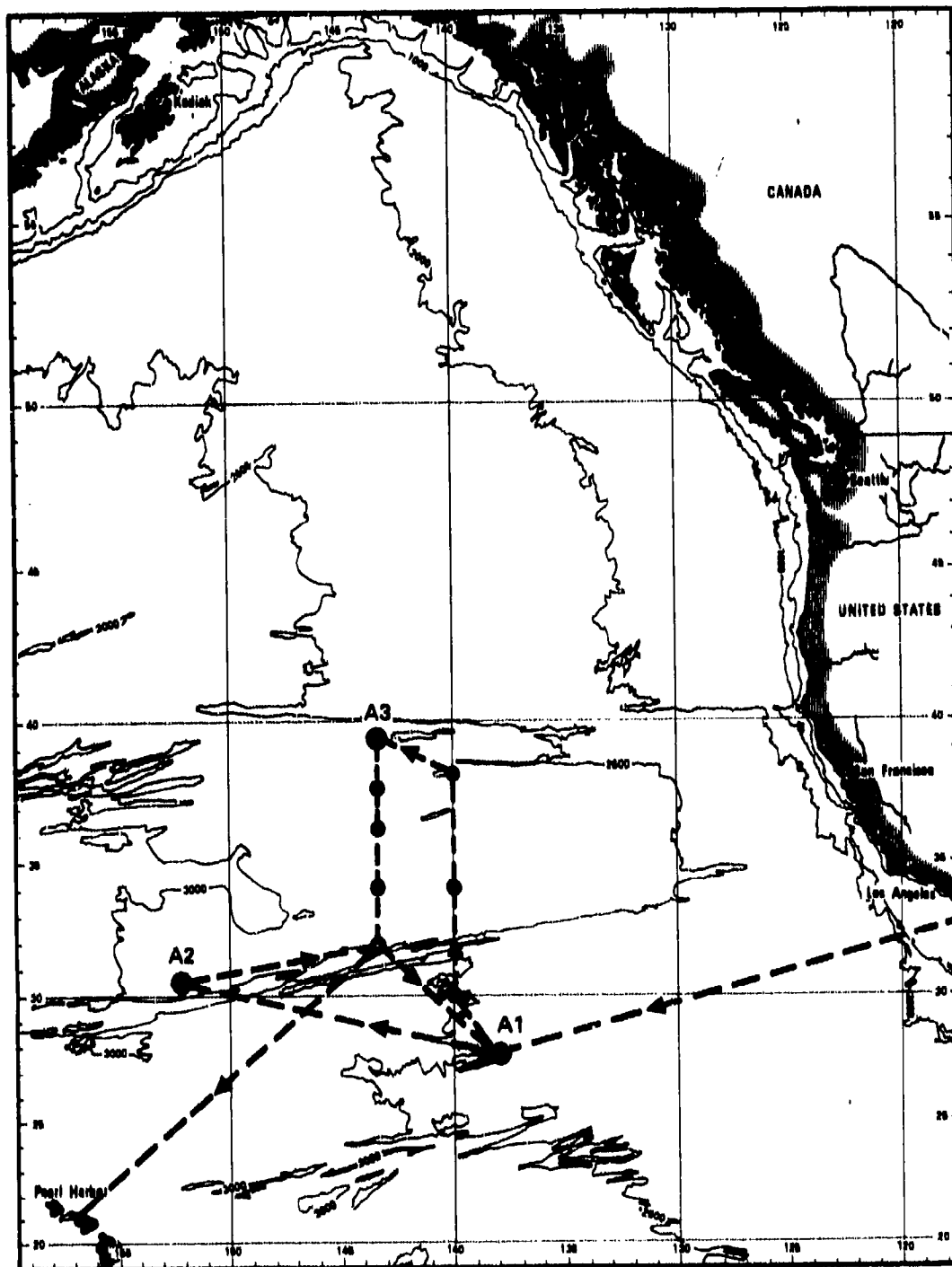


Figure A-4. (C) R/V MOANA WAVE Track: San Diego to Hawaii (U)

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APPENDIX B

AIRCRAFT OPERATIONS (U)

(C) The primary objectives of the aircraft operations in this Exercise are surveillance of surface shipping and the acquisition of environmental data. Aircraft operations will include aircraft and flight crews supplied by NAVOCEANO VXN-8 and by COMPATWINGSPAC. Exercise flight events are given in Tables B-1 and B-2. Aircraft tracks are given in Figures B-1 through B-8. All VXN-8 tracks are denoted by the prefix T and all VP tracks by the prefix P. All aircraft sorties will be flown from Elmendorf AFB, NAS Moffett Field, or NAS Barbers Point.

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Table B-1

(C) VXN-8 Operation Schedule (U)

Date-Time Group	Track	Origin	Termination
101500-110300Z Sep	TC	NAS Moffett Field	NAS Barbers Point
121700-130500Z	TD	NAS Barbers Point	NAS Barbere Point
141700-150500Z	TE	NAS Barbers Point	NAS Barbers Point
161700-170500Z	TE	NAS Barbers Point	NAS Barbers Point
181700-190500Z	TG	NAS Barbers Point	NAS Moffett Field
201500-210300Z	TA	NAS Moffett Field	Elmendorf AFB
221700-230500Z	TH	Elmendorf AFB	NAS Moffett Field
241500-250300Z	TA	NAS Moffett Field	Elmendorf AFB
261700-270500Z	TH	Elmendorf AFB	NAS Moffett Field
281500-290300Z	TJ	NAS Moffett Field	NAS Moffett Field
301500-010300Z Oct	TA	NAS Moffett Field	Elmendorf AFB
041700-050500Z	TK	Elmendorf AFB	NAS Moffett Field

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Table B-2
(C) Fleet Aircraft Operations Schedule (U)

Date-Time Group	Track	Origin	Termination
141710 -150510Z Sep	PA	NAS Barbers Point	NAS Barbers Point
141720 -150520Z	PB	NAS Barbers Point	NAS Barbers Point
161710 -170510Z	PA	NAS Barbere Point	NAS Barbers Point
161720 -170520Z	PB	NAS Barbers Point	NAS Barbers Point

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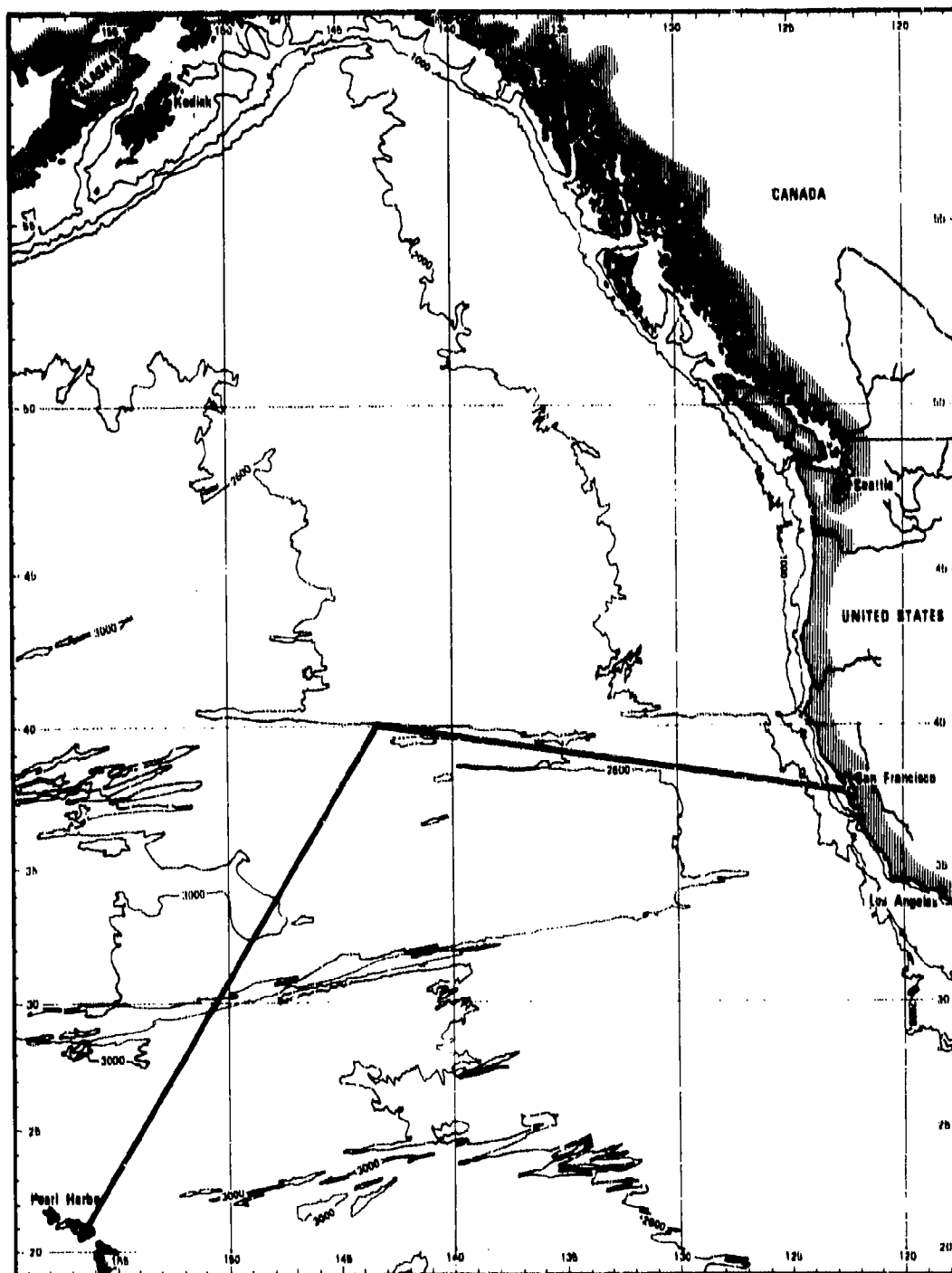


Figure B-1. (C) VXN-8 Aircraft Tracks TC and TC (U)

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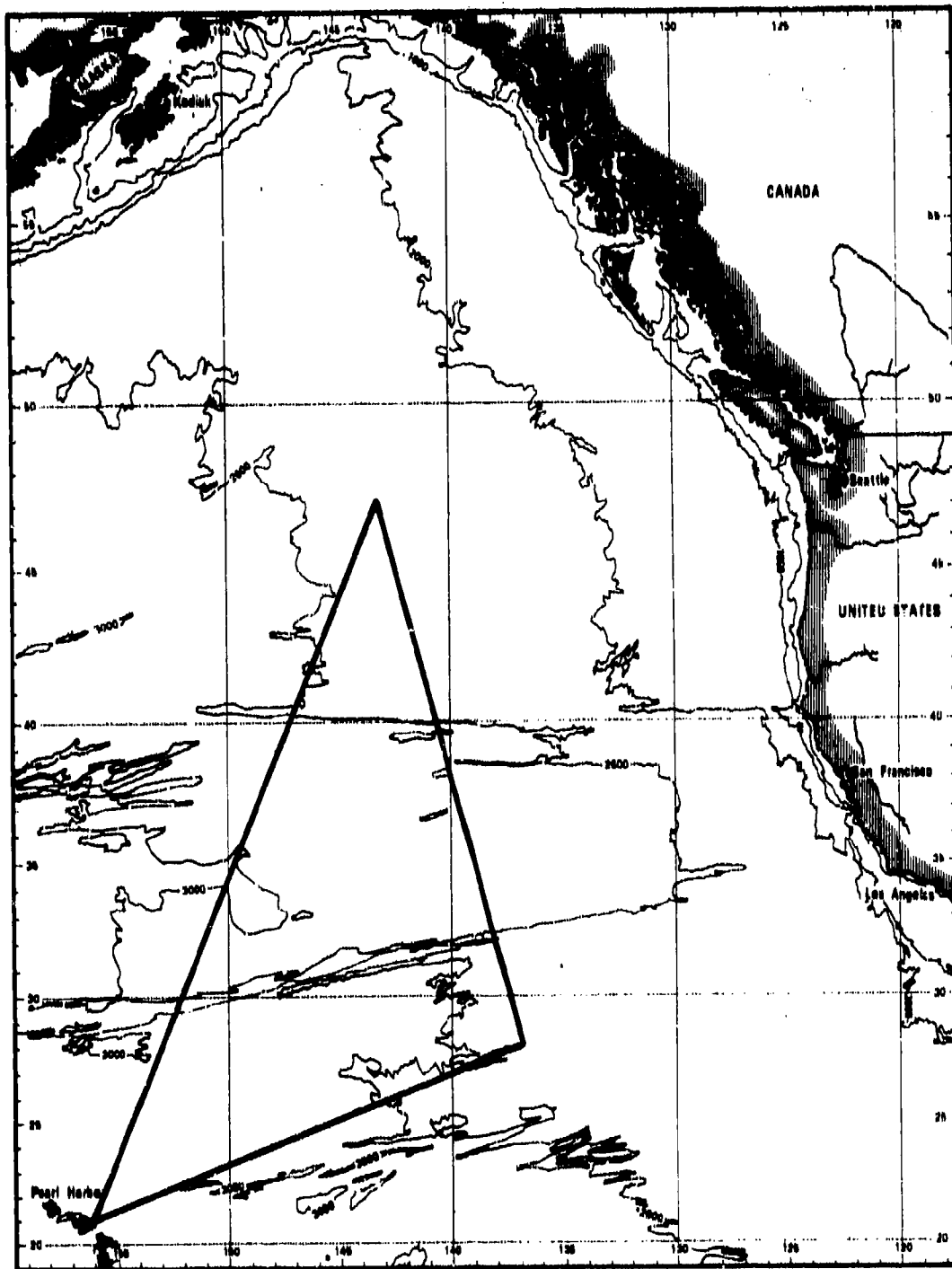


Figure B-2. (C) VXN-8 Aircraft Track TD (U)

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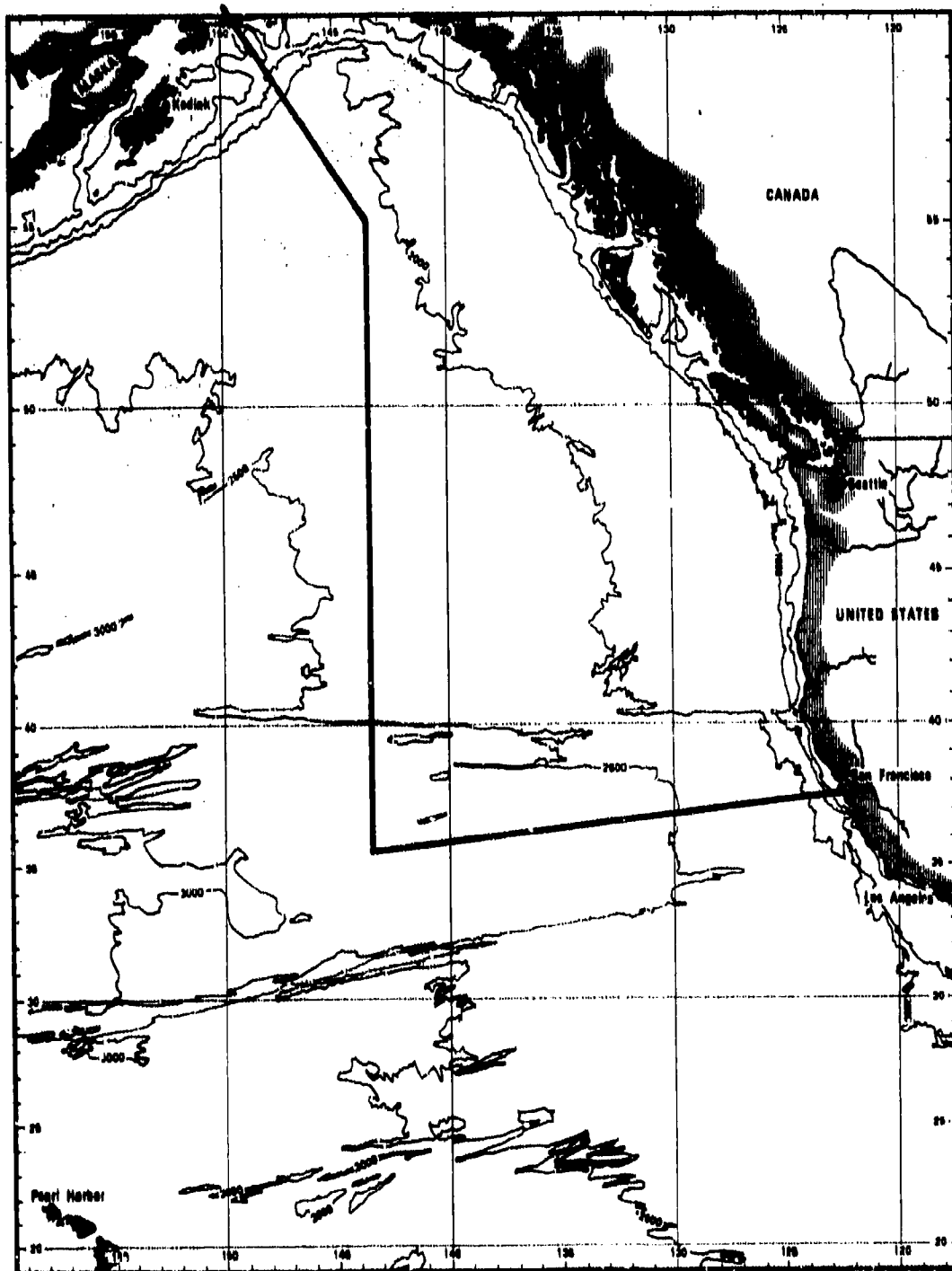


Figure B-4. (C) VXN-8 Aircraft Tracks TA and TH (U)

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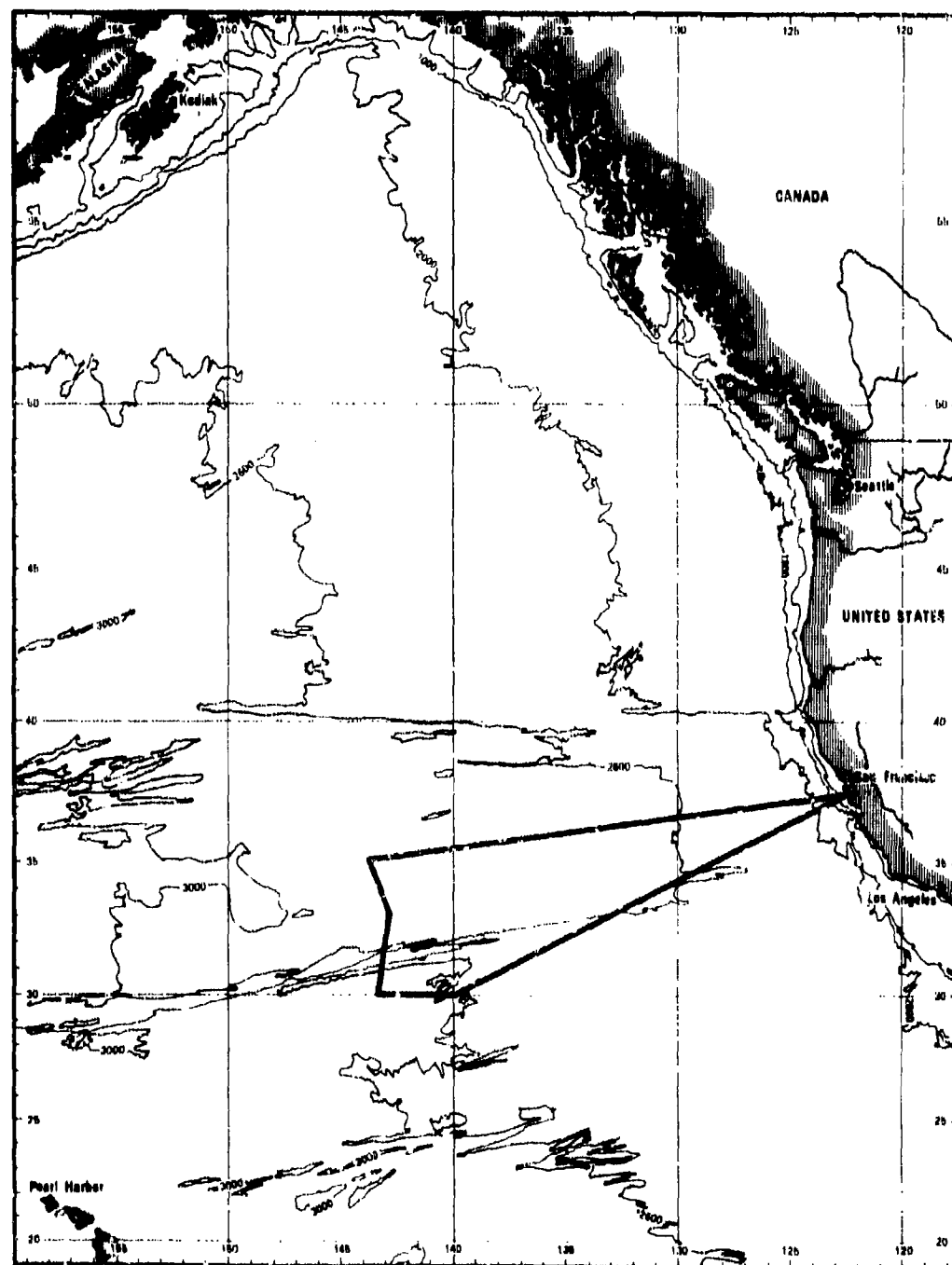


Figure B-5. (C) VXN-8 Aircraft Track TJ (U)

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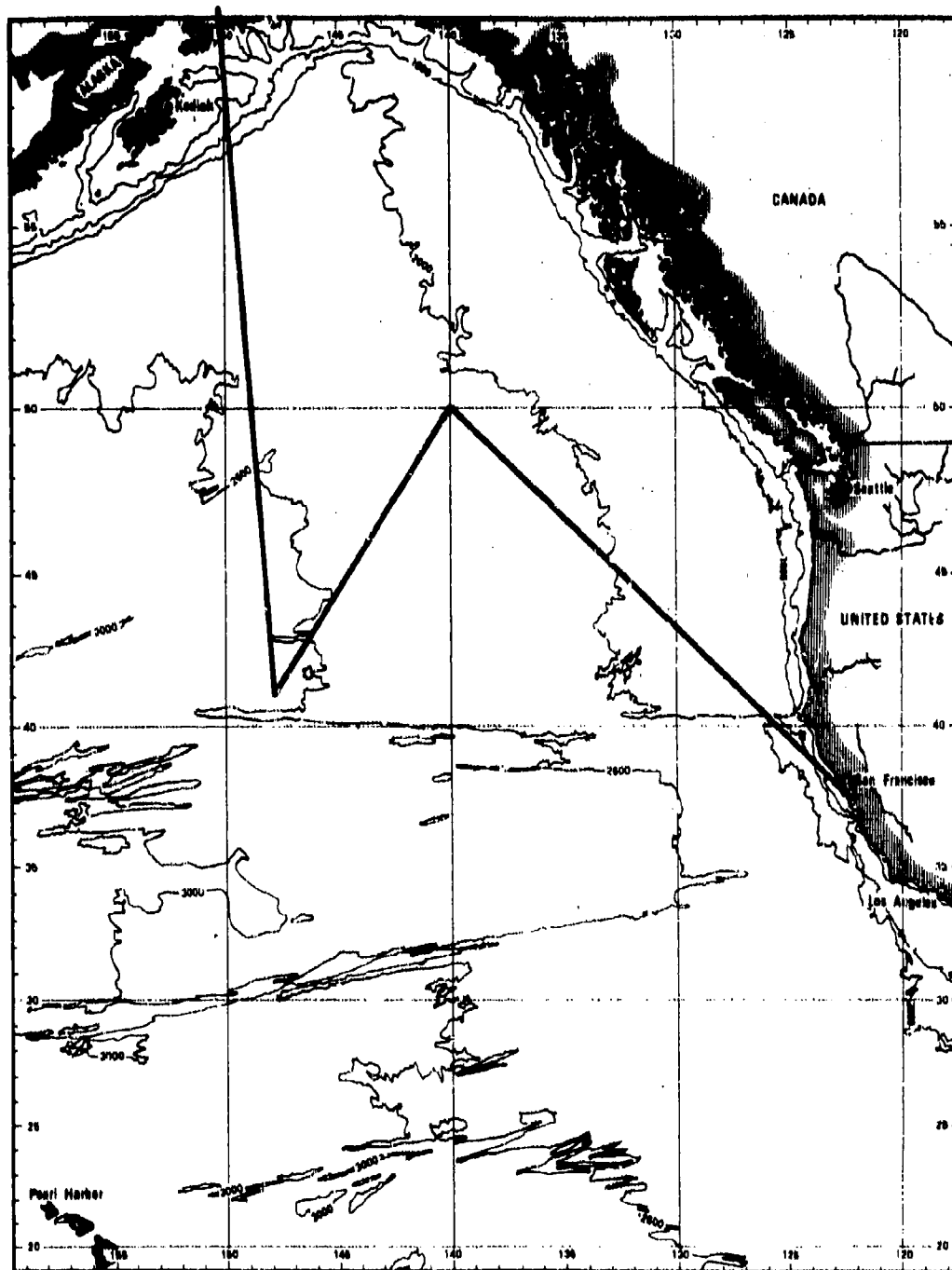


Figure B-6. (C) VXN-8 Aircraft Track TK (U)

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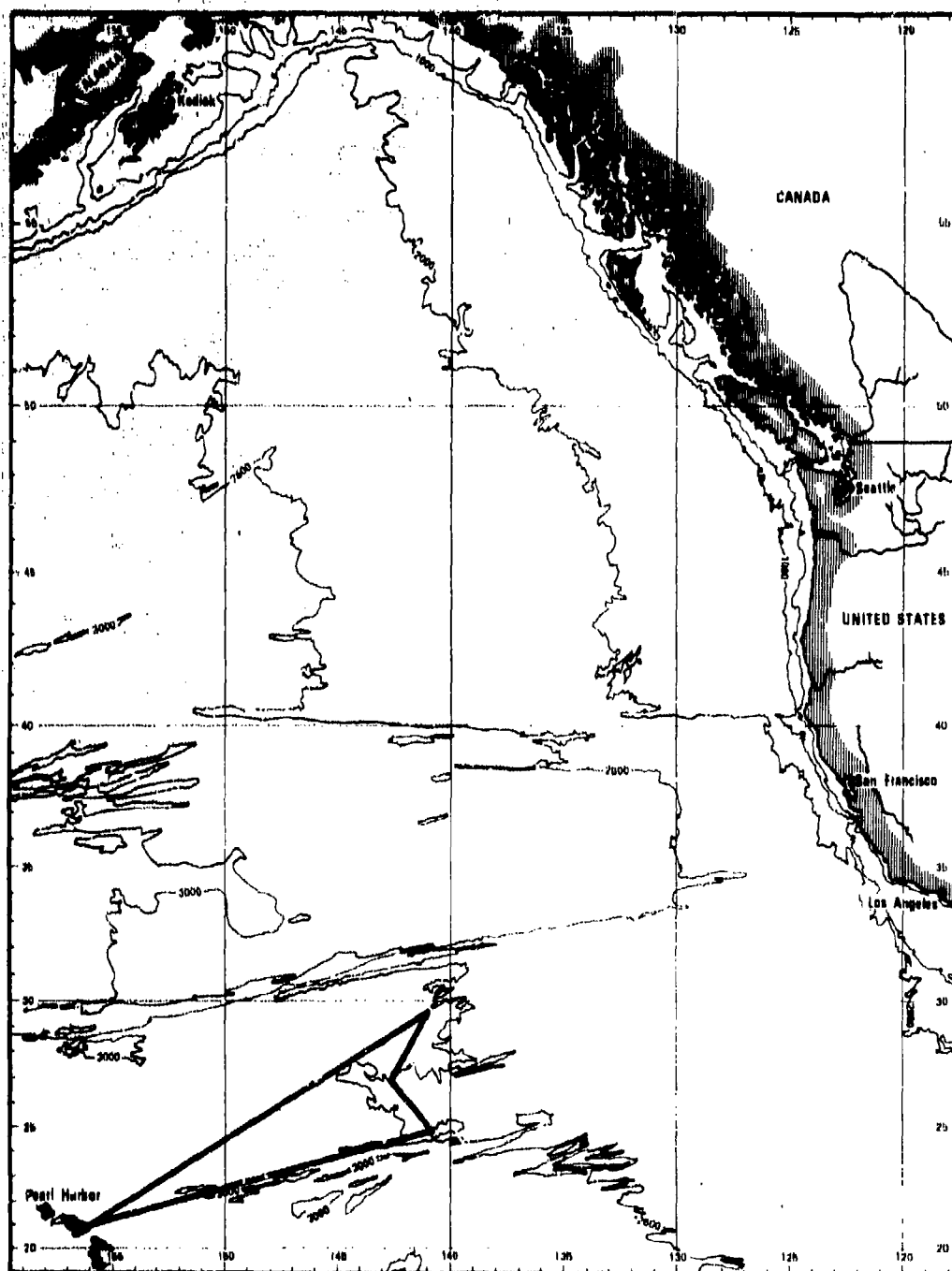


Figure B-7. (C) VP Aircraft Track PA (U)

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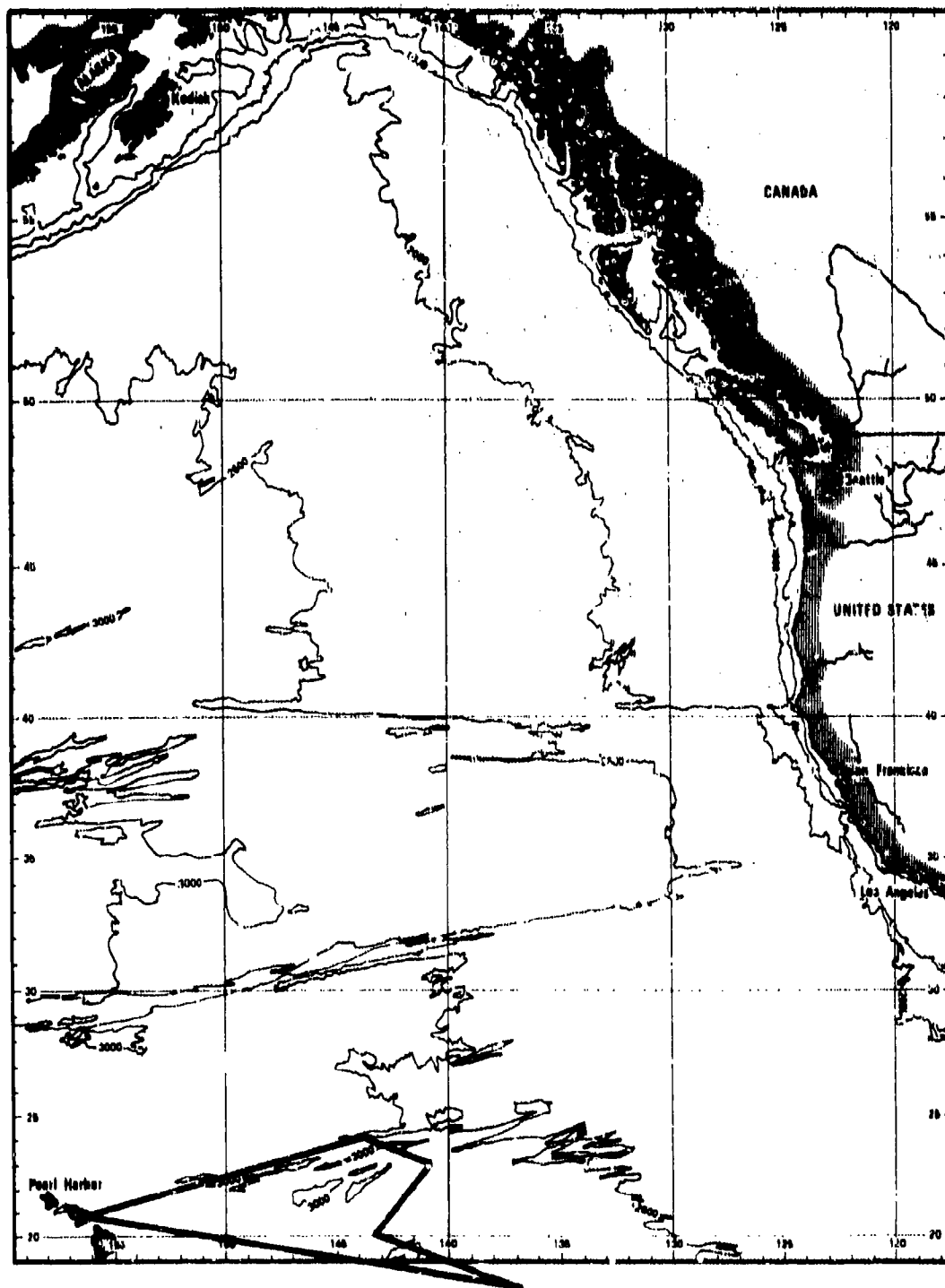


Figure B-8. (C) VP Aircraft Track PB (U)

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APPENDIX C

OTH RADAR OPERATIONS (U)

(C) Stanford Research Institute will operate the WARF radar for the purpose of ship detection over three areas approximately 5 degrees by 5 degrees on 5 separate days. SRI will subsequently deliver charts of the detected ships in those areas to representatives of LRAPP. The areas and periods of operation are given in Table C-1 and are shown in Figure C-1.

(C) Naval Research Laboratory will operate the SEA ECHO radar for the purpose of ship detection over two areas approximately 5 degrees by 5 degrees on 5 separate days. NRL will subsequently deliver charts of the detected ships in those areas to representatives of LRAPP. The areas and periods of operation are given in Table C-2 and are shown in Figure C-1.

(C) Both SRI and NRL will provide surface ship density distribution data for their areas. The data will be in tabular form, and ship populations will be given for each resolution cell within the (larger) surveillance area. These data will be stated for a measurement epoch whose duration for each surveillance area is sufficiently long to provide a good probability of detection. Charts that identify the geodesy of each measurement cell will be provided.

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Table C-1

(C) WARF Radar Operation Schedule (U)

Date-Time Group	Area	
101600-110400Z Sep	35°00' - 40°00'N	140°00' - 145°00'W
111600-120400Z	30°00' - 35°00'N	140°00' - 145°00'W
121600-130400Z	30°00' - 35°00'N	140°00' - 145°00'W
131600-140400Z	25°00' - 30°00'N	140°00' - 145°00'W
141600-150400Z	25°00' - 30°00'N	140°00' - 145°00'W

Table C-2

(C) SEA ECHO Radar Operation Schedule (U)

Date-Time Group	Area	
201600-210400Z Sep	50 - 50°N	140 - 145°W
211600-220400Z	50 - 55°N	140 - 145°W
221600-230400Z	45 - 50°N	140 - 145°W
231600-240400Z	45 - 50°N	140 - 145°W
241600-250400Z	50 - 55°N	140 - 145°W

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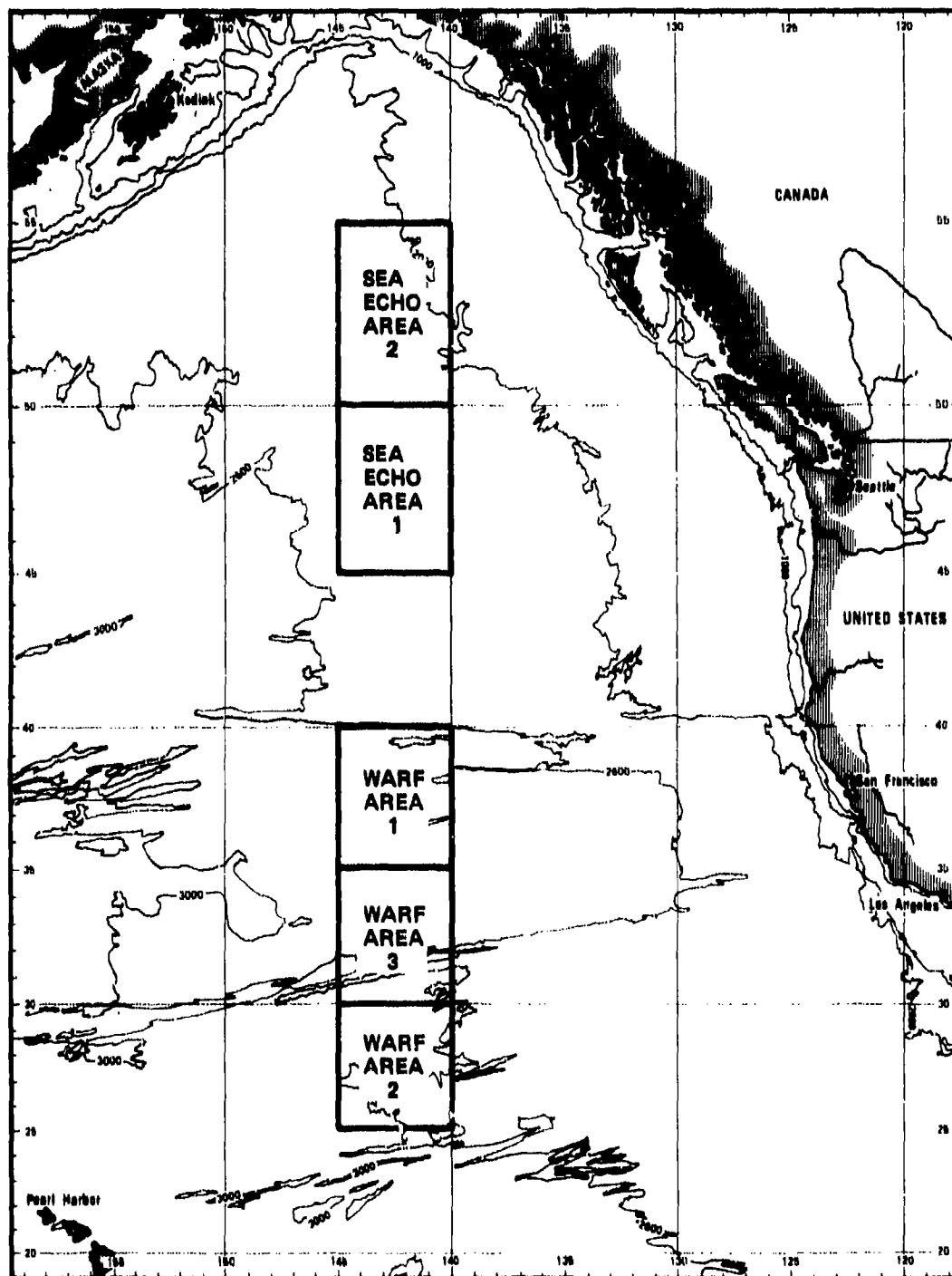


Figure C-1. (C) OTH Radar Coverage (U)

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APPENDIX D

SHORE STATION OPERATIONS (U)

(C) Data will be recorded at 1321, 1322, 1323, and 2411 during selected Exercise events. Station recorders will be used to obtain limited data at 1321, 1322, 1323, 1511, 2321, and 2411 during selected events.

(C) Table D-1 indicates the schedules for data recording at a number of shore stations. NUC will use DAPAAN to record data from 1321, 1322, and 1323. NAVOCERANO will use a 14-track tape recorder to record data from 2411. Shore station personnel will use the station 7-track tape recorders to record selected data from 1321, 1322, 1323, 1511, 2321, and 2411.

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Table D-1

(C) Shore Station Operations Schedule (U)

Event	Data Recorders				Station Recorder					
	1321	1322	1323	2411	1321	1322	1323	1511	2321	2411
200	NUC	NUC	NUC	NOO	-	-	-	-	-	-
300	NUC	NUC	NUC	NOO	-	-	-	SP	SP	-
400	NUC	NUC	NUC	NOO	-	-	-	-	-	-
500	NUC	NUC	NUC	NOO	-	-	-	SP	SP	-
600	NUC	NUC	NUC	NOO	-	-	-	-	-	-
700	NUC	NUC	NUC	NOO	-	-	-	-	-	-
800	NUC	NUC	NUC	NOO	-	-	-	-	-	-
900	NUC	NUC	NUC	NOO	-	-	-	-	-	-
1200	-	-	-	-	SP	-	SP	SP	SP	SP
1300	-	-	-	-	-	SP	SP	SP	SP	SP
1500	-	-	-	-	SP	-	SP	SP	SP	SP
1600	-	-	-	-	-	SP	SP	SP	SP	SP
1900	-	-	-	-	-	SP	SP	SP	SP	SP
2000	-	-	-	-	SP	SP	-	SP	SP	SP
2200	-	-	-	-	SP	SP	-	SP	SP	SP
2300	-	-	-	-	SP	-	SP	SP	SP	SP
2400	-	-	-	-	SP	-	SP	SP	SP	SP

SP = Station Personnel

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APPENDIX E SECURITY GUIDELINES (U)

(C) Classification of plans, communications, logs, and reports will be indicated for each page or paragraph thereof. The lowest classification permitted will be used, and unclassified portions will be handled separately where it will expedite providing instructions or recording data. Classified material is subject to the General Declassification Schedule of Executive Order 11652. The following aspects of the Exercise will be classified as shown.

1. Unclassified

- Name of the Exercise, CHURCH OPAL, when not associated with classified material.

NOTE: CHURCH OPAL will be encoded in voice transmissions.

- Participating Commands, Laboratories, and Institutions.
- Individual ships and aircraft.
- Scientific (non-tactical) measurement systems used.
- Commercial sound sources used.
- Data on temperature, salinity, depth, sound speed, bathymetry, sub-bottom profile, other geological and geophysical data, weather and sea-surface observations, shipping density.
- Reports of environmental data or other reports that do not relate environmental effects to acoustic phenomena obtained during these events.
- Ambient noise data when not identified with locations.
- Unannotated raw acoustic data such as strip charts, magnetic tapes of ambient noise, shot arrival, and signal arrival times.

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NOTE: Care will be taken to ensure that there is no coupling of UNCLASSIFIED raw data to processed data, which would result in compromising the acoustic portions of this Exercise.

NOTE: Call signs will be used in voice communications during the Exercise in accordance with the CHURCH OPAL Exercise Plan, Appendix C1, Communications.

2. Confidential

- Any link of Exercise CHURCH OPAL with the Exercise area.
- Ships and aircraft schedules and tracks until after execution of each exercise phase when they are declassified.
- Processed acoustic data, such as ambient noise levels, propagation loss, level versus distance information, depth, frequency, and output level of sound sources, including charge size.

3. Secret

- Systems implications of the data obtained.

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APPENDIX F

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Austin, TX 78712

Woods Hole Oceanographic
Institution
Attn: Dr. E. E. Hays
Woods Hole, MA 02543

Xonics, Inc.
Attn: Mr. S. Kulek
6837 Hayvenhurst Avenue
Van Nuys, CA 91406



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OFFICE OF NAVAL RESEARCH
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IN REPLY REFER TO
5510/1
Ser 43/885
03 Dec 03

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Subj: DECLASSIFICATION OF CHURCH OPAL DOCUMENTS

Ref: (a) SECNAVINST 5510.36

Encl: (1) Partial List of CHURCH OPAL Documents

1. In accordance with reference (a), a declassification review has been conducted on a number of classified CHURCH OPAL documents.
2. The CHURCH OPAL documents listed in Part 1 of enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

Classification changed to UNCLASSIFIED by authority of the Chief of Naval Operations (N774) letter N774D/3U630173, 11 September 2003.

DISTRIBUTION STATEMENT A: Approved for Public Release; Distribution is unlimited.

3. If other CHURCH OPAL documents are located in your repositories, their markings should be changed and a copy of the title page and a notation of how many pages the documents contained should be provided to Chief of Naval Research (ONR 43) 800 N. Quincy Street, Arlington, VA 22217-5660. This will enable me to maintain a master list of downgraded/declassified CHURCH OPAL reports.
4. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

PEGGY LAMBERT
By direction

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Title: CHURCH OPAL ENVIRONMENTAL ACOUSTIC SUMMARY

Formerly SECRET

Author: Unknown

Originator: Naval Ocean R&D Activity

Ref. No.: LRAPP RS 77-002

Date: April 1977

Available at NRL (529148), MC/NAVOCEANO (85006869) and ARL:UT (51577)

Title: CHURCH OPAL EXERCISE OPERATIONS SUMMARY AND DATA INVENTORY

Formerly SECRET

Author: Unknown

Originator: Xonics, Inc.

Ref. No.: Xonics 1099

Date: October 1976

Available at MC/NAVOCEANO (85028383)

Title: HORIZONTAL DIRECTIONALITY OF AMBIENT NOISE DURING THE CHURCH OPAL EXERCISE

Formerly SECRET

DTIC No.: AD C017 835

Author: Wagstaff, R. A.

MCS No.: 85007295

Originator: Naval Ocean Systems Center

Ref. No.: NOSC TR394

Date: October 1978

Available at MC/NAVOCEANO (85007295)

Title: OTH RADAR SURVEILLANCE AT WARF DURING THE LRAPP CHURCH OPAL EXERCISE

Formerly SECRET

DTIC No.: AD C010 483

Author: Barnum, J. R.

MCS No.: 85010085

Originator: Stanford Research Institute

Ref. No.: TR39S231

Date: March 1977

Available at MC/NAVOCEANO (85010085) and NRL (528986)

Title: CHURCH OPAL Exercise Summary, 1 September 1975 - Xonics, Inc

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DTIC No.: AD C004 343

Available at NRL (516165), ARL:UT (??) and MC/NAVOCEANO (??)

Title: CHURCH OPAL EXERCISE PLAN

Formerly SECRET

Author: none

Originator: Xonics, Inc and Office of Naval Research

Ref No: Xonics 1101

Date: August 1975

Available at NRL (521309), ARL:UT (55397) and MC/NAVOCEANO (??)