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SUMMARY OF FREDDEX DEVELOPMENTS PRIOR TO AT-SEA PHASE.(U)
SEP 79 W MOSELEY, D DEL BALZO, J PERKINS

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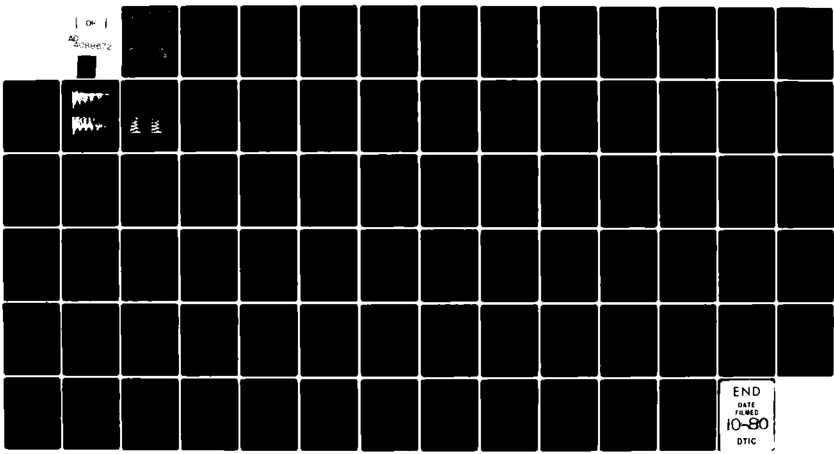

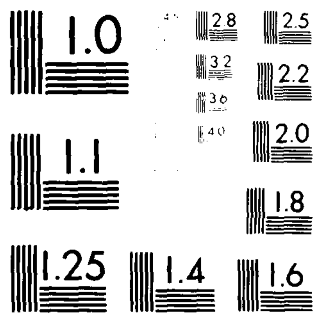
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FREDDEX REPORT #1
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SUMMARY OF FREDDEX DEVELOPMENTS PRIOR TO AT-SEA PHASE

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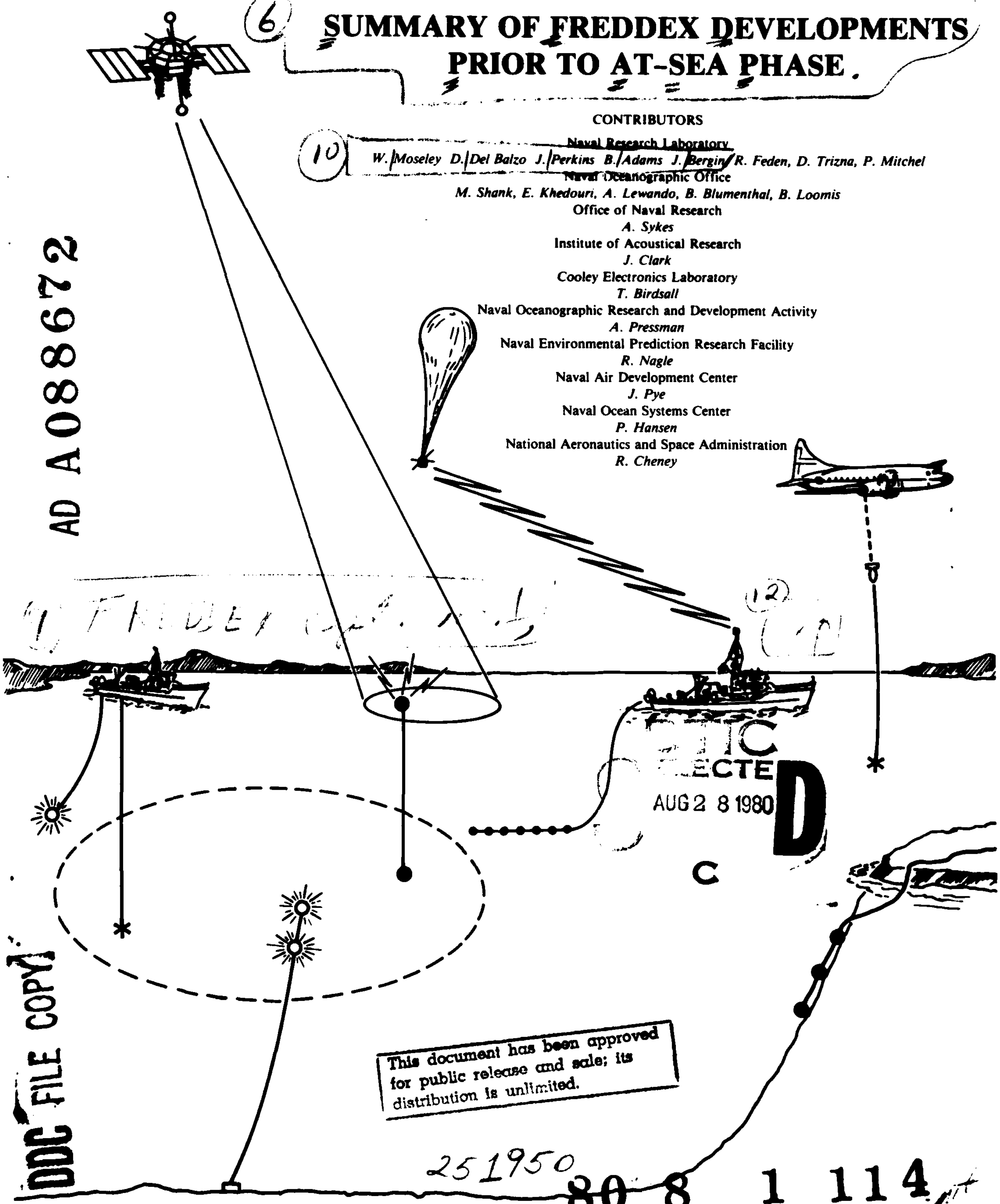

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BACKGROUND

The long range objective of exercises such as FREDDEX, Front and Eddy Exercise, is the capability to predict the environmental influences in an ocean basin on acoustic array performance through remote sensing of ocean features and environmental and acoustic models. In response to a program outlined by the DDF Block Principal, the Naval Material Command established a working group on mesoscale environmental effects on ASW. An outgrowth of the working group was the initiation of planning for FREDDEX. In addition to developing basic knowledge on the oceanographics of large scale ocean features and their acoustic impact, this exercise brings together the diverse participants necessary to indicate our present ability to locate, monitor, and predict the influences of these features on surveillance systems. The ability to exploit ocean features in ASW and USW operations will require exercises such as FREDDEX where the knowledge and resources of many participants are being brought together for efficiency and mutual support.

This document summarizes the development to date of FREDDEX. It consists of the following information:

1) Overall objectives
2) Participants
3) Equipment
4) Exercise events
5) Initial acoustic modeling
6) Initial measurements
7) Some individual objectives
8) Detailed operation plans

Trip reports containing a chronology of events and some preliminary measurement results will be gathered from the various participants and be bound together to form a FREDDEX preliminary report. Those expected to contribute to that document and the platforms for which they are responsible are:

D. Del Balzo - USNS HAYES
R. Feden - USNS LYNCH
B. Blumenthal - R/V ENDEAVOR
S. Kovacs - NRL Aircraft
R. Doblar - NAVOCEANO Aircraft
J. Bergin - Satellite Remote Sensing
J. Clark - Fixed Bottom Arrays

OBJECTIVES

The performance, resolution, and combined source locating ability of a high-resolution mid-frequency towed array, and conventional systems, as influenced by extensively studied strong mesoscale features are the total objective of FREDDEX. The effects of a Gulf Stream ring on the MF towed array will be investigated through measurements of beam splitting and width, side lobe suppression, and array distortion.

Measurements will be made which will assist in developing and improving environmental and stochastic acoustic models. Also, remote sensing of ocean features by over-the-horizon radar and satellites will be tested with ground truth measurements.

PARTICIPANTS

The number and diversity of participating organizations is great. It is a loosely knit group, each with their own objectives, combining to conduct the operation. The technical areas, organizations, principal investigators and supporting organizations are:

- FREDDEX Senior Scientist, NRL, W. Moseley, NAVMAT.

- Surveillance ASW relative to very high resolution towed arrays, NRL, D. Del Balzo, NAVMAT.

- Environmental effects on tactical and surveillance sonars and improvements to environmental survey procedures, NAVOCEANO, M. Shank, CNOC.

- Ambient noise in entrained cold water, NAVOCEANO, M. Shank, CNOC.

- Environmental effects on fixed sonar receivers, IAR (Institute for Acoustical Research), J. Clark, ONR.

- Spatial variability of mesoscale oceanographic environmental features, NRL, J. Bergin, ONR.

- Influence of ocean dynamics on stochastic acoustic propagation, NRL, R. Baer, ONR.

- Monitoring mesoscale oceanographic features, with low frequency over-the-horizon radar, NRL, D. Trizna, ONR.

- Satellite remote sensing of mesoscale oceanographic features using both infrared and visual measuring devices, NRL, V. Noble, ONR; NORDA, A. Pressman, ONR; NEPRF, R. Nagles, NAVMAT.

- Low-frequency directional surface scattering and basin reverberation, NRL, E. Franchi, NAVELEX.

- Noise surface statistical characterization, NRL, R. Heitmeyer, NAVMAT.

- Multi-sensor correlation processing, NOSC, P. Hansen, NAVELEX.

- Non-satellite communication utilizing weather balloons, NADC, J. Pye, NAVELEX.

- MF array and other equipment are supplied by ARPA, PME 124, NRL, and APL Johns Hopkins.

EQUIPMENT

The assets that will be involved in making measurements include three ships (USNS HAYES, USNS LYNCH, and R/V ENDEAVOR). It also includes four aircraft (two NRL, two NAVOCEANO). It will include the mid-frequency towed array, at least two shore stations, five moored sources, a towed source (the HLF-3), over-the-horizon radar, satellite remote sensing involving GOES, NOAA, DMSP and NIMBUS satellites, COSRAM buoys, and an additional balloon RF communication experiment.

EXERCISE EVENTS

On 7 and 8 September, 1978, an initial meeting was held at NRL to establish objectives and participants in the exercise. On 11 October, further exercise definition and planning occurred, and statements of specific responsibility were obtained from the principals and major collaborators. On 5 November the parameters for pretrip acoustic computer modeling were selected. On 25 January, 1979, at NAVOCEANO NSTL, the modeling results were reviewed to pick particular operation parameters.

Following the modeling session, which selected several specific operation parameters, the first aircraft flights were flown by NAVOCEANO between 8 and 19 March. These flights surveyed the broad area under consideration, located three eddies, and resurveyed the strongest of the three. Immediately after those aircraft flights, with that available information, a meeting was held at NAVOCEANO on 23 March to make the first selection of specific ship tracks and frequencies. Satellite monitoring began simultaneously with the first aircraft tracks. Regular outputs of satellite photos have been obtained from NEPRF on a weekly basis. These photos identified several new warm eddies north of the Gulf Stream, but only one photo had any indication of a cold eddy. It did, in fact, appear to be what is now the primary eddy, but the indication was marginal. During March and April and into the beginning of May, cloud cover in the area was very severe, hindering the satellite sensing efforts.

In the initial detailed survey of the primary eddy, a COSRAM buoy was deployed. This buoy has a surface transmitter and a subsurface drogue. The transmissions are monitored by the NIMBUS satellite. The actual monitoring is conducted by NASA, and they give a daily update on the position of the buoy. The efforts of NAVOCEANO and NASA have been a considerable aid in keeping track of the eddy.

A resampling of the eddy by NRL aircraft occurred on 23 and 24 April. Further detailed information from the AXBT's was obtained during that survey. Some of the objectives of the oceanographic and remote sensing community are to determine models for the evolution and dynamics of these eddies and test their ability to sense and track these dynamics from the remote sensing platforms. Several concentrated looks both from the satellites and from aircraft spread over a number of months may enable estimates of the correlation between surface observed features and subsurface ground truth measurements.

On 24 and 25 April, after the aircraft flights, the first detailed Op Plan meeting was held. At this meeting not only were the tracks, frequencies, source depths, receiver depths, orientations, and general geometry discussed, but the other normal operational considerations such as communications frequencies, rendezvous with aircraft, etc. were discussed in great detail, and the first preliminary Op Plans were drawn up.

On 14 and 15 May, three weeks later, NRL aircraft surveyed the eddies again while NAVOCEANO indicated that satellite measurements may have found a new eddy. The primary selected eddy, on the basis of the aircraft measurements, is quite strong. It shows a temperature difference of almost 10° at 300 meters; that is a sound speed difference of almost 45 meters per second inside to out. However, it was located NNE of Bermuda, and caused the transit time of all the ships coming from the East Coast to be quite long. The new eddy, which had not been as yet surveyed by aircraft for ground truth measurements, was somewhat closer to the East Coast providing more time on station for environmental and acoustic measurements. Both the original primary eddy and this new eddy were checked out with aircraft flights on 14 and 15 May. The strength and more detailed knowledge of the primary eddy lead to its eventual selection as the focal point of the exercise.

On 21 May, fourteen days prior to the sailing dates of the ships, the final presail briefing was held. On 21, 23, and 25 May, the final presailing survey by NAVOCEANO aircraft of the eddy features occurred. These flights were coordinated with the over-the-horizon radar people to provide several tracks across the north wall of the Gulf Stream to support tests of the feasibility of OTH radar surface current measurements. The three ships were scheduled to depart on 3 and 4 June; LYNCH from Newport, R.I., on the 3rd, HAYES from Cheatham, VA., on the 4th, and ENDEAVOR from Narragansett, R.I., on the 4th. All three ships will leave with the latest remote environmental sensing information in hand. The planned tracks described below are tabulated in the Event Schedule and charted in Figures 1 and 2.

The first operation on the way out by HAYES will be to conduct the RF balloon communication experiment for NADC. While HAYES is conducting the balloon experiment, LYNCH will deploy and tow the source through the north wall of the Gulf Stream giving some additional information on the effect of the front to receivers in warm water south of the Gulf Stream and cold water north of the Gulf Stream. LYNCH will continue with the source in the water at all times during the remainder of the exercise, providing it does not unexpectedly interfere with the oceanographic work.

While HAYES is deploying the moored sources, LYNCH and ENDEAVOR will be conducting detailed on-site environmental measurements. ENDEAVOR will be using shallow T7 XBT's and making deep CTD stations. LYNCH will be sampling the eddy in a pattern similar to that of a pinwheel, launching both deep and shallow XBT's, T5's, and T7's, in the eddy. Simultaneously, synoptic shallow looks with AXBT's will be made from NAVOCEANO aircraft.

Having completed the initial detailed environmental survey, LYNCH and HAYES will operate in tandem as, respectively, source and towed array receiving platforms. Simultaneously, attention will be directed towards the acoustics from the two receivers manned by IAR. At this time LYNCH will execute a pattern towing its source into and out of the eddy. All the receivers will be monitoring not only the towed source, but also the five moored sources. During these acoustic operations ENDEAVOR will perform a second detailed environmental survey of the eddy in a pinwheel pattern. Following the initial acoustic operations with the towed array external to the eddy, LYNCH will begin a third detailed environmental survey of the eddy in the pinwheel pattern, simultaneously towing the HLF source while the towed array will be operated inside the eddy for a second phase of acoustic operations.

After the second phase of acoustic operations, HAYES will retrieve the moored sources. In doing so, as well as during the deployment, it will make several passes through the eddy taking deep and shallow XBT information. LYNCH will make two passes along arc runs useful to the other stations, transmitting from the HLF-3 source. ENDEAVOR, both during the second phase of acoustic operations and immediately following, will continue detailed CTD work both through the eddy and along the paths useful to the other stations. LYNCH and ENDEAVOR are scheduled to inport Bermuda on the 21st, and HAYES is scheduled to arrive at Cheatham on the 25th.

OUTLINE OF EVENTS DURING SHIP PHASE

TIME (Z)	EVENT
03/1030	LYNCH departs Newport
04/1400	ENDEAVOR departs Narragansett
04/1200	HAYES departs Cheatham
04/1300	LYNCH deploys HLF-3 towed source at S
05/1030	HAYES launches balloons
06/1230	HAYES deploys 230 Hz source at C
06/1900	LYNCH begins first pinwheel sampling pattern
08/0330	HAYES deploys 224, 230 Hz sources at A
08/1600	HAYES deploys 162, 227 Hz sources at B
09/1030	HAYES deploys MF array
09/2100	LYNCH begins acoustic tow pattern in eddy
09/1400	ENDEAVOR begins second pinwheel sampling pattern
11/1400	First SUS Flight
15/1400	Second SUS Flight
16/2130	LYNCH begins third pinwheel sampling pattern
21/1130	HAYES retrieves MF array and sources at B
21/1800	LYNCH retrieves HLF-3 source
21/2330	LYNCH arrives at Bermuda
22/1000	HAYES retrieves sources at A
24/0830	HAYES retrieves sources at C
25/2330	HAYES arrives at Cheatham
30/2100	ENDEAVOR arrives Narragansett

Ship Tracks are shown in Figures 1 and 2.

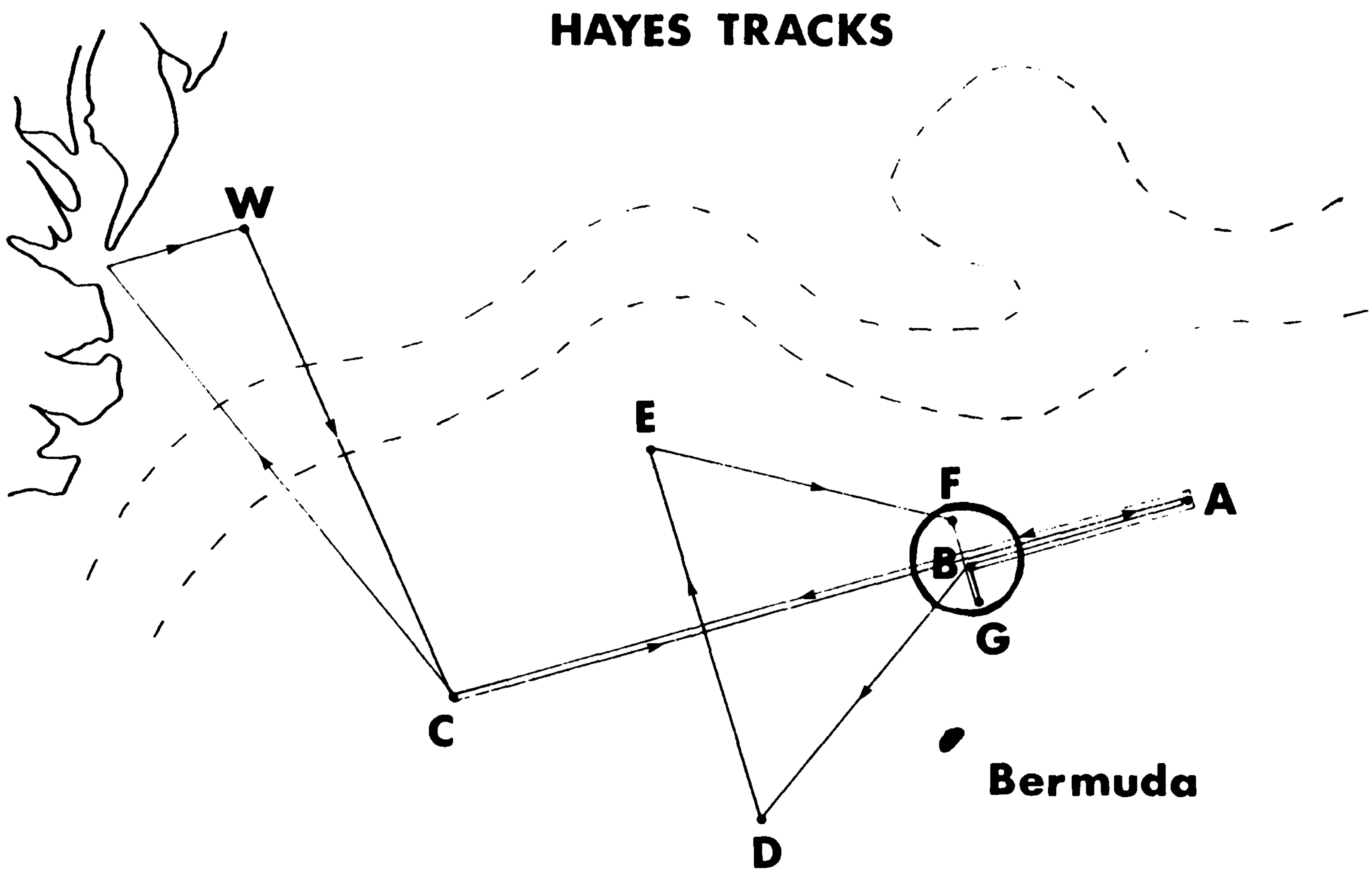

Fig. 1 - FREDDEX Tracks for the USNS HAYES.

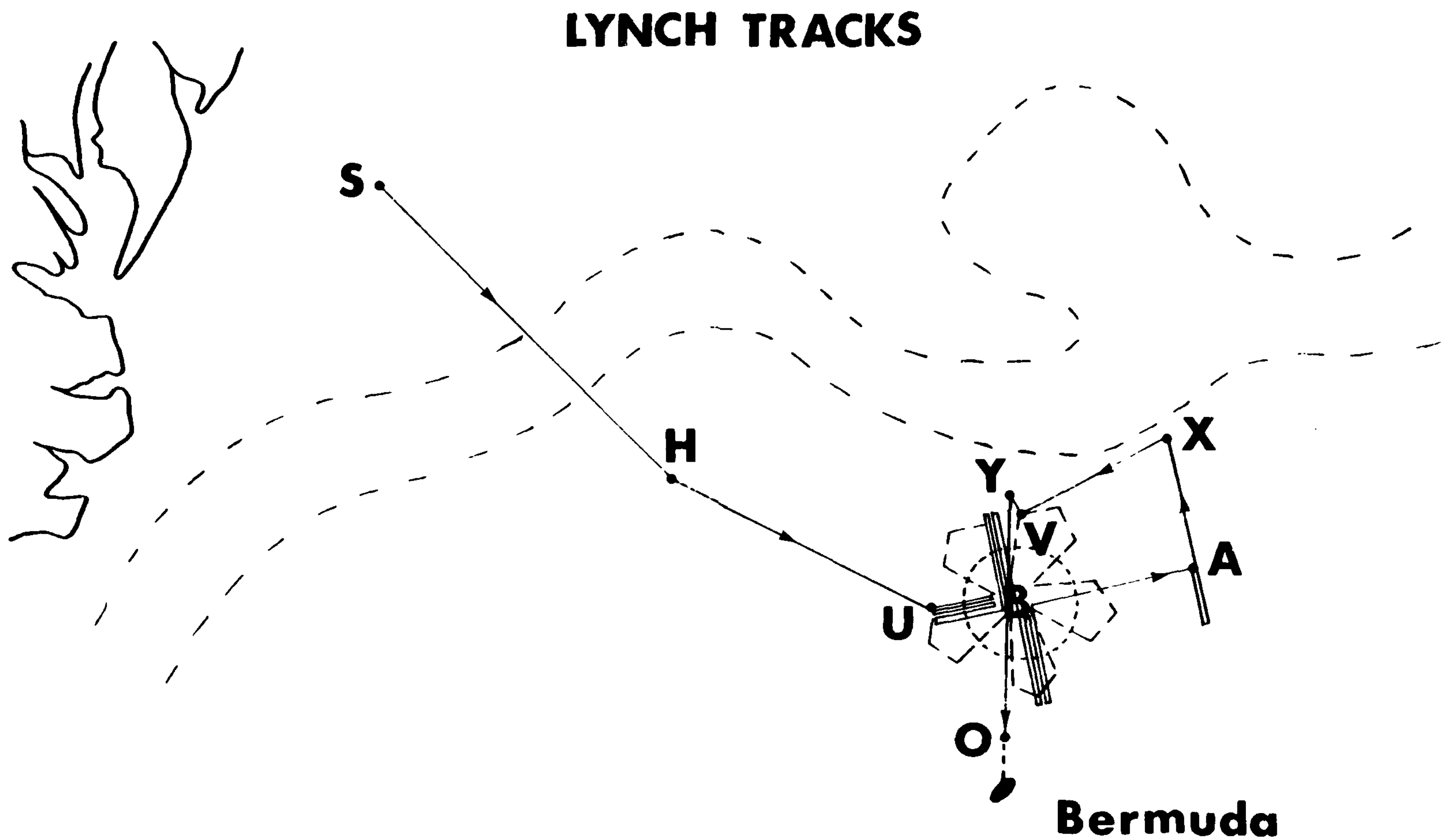

Fig. 2 - FREDDEX Tracks for the USNS LYNCH

ACOUSTIC MODELING

At the modeling planning meeting an observed eddy thermal section taken by NAVOCEANO was selected for pretrip modeling. This moderately strong eddy was considered characteristic of the area in June. It contained variations in iso-sound speed levels of 500 meters in depth, with maximum sound speed change at a given depth of 30-35 meters per second, and the temperature variation at 500 meters approximately 7 to 8 degrees. Figure 3 shows the sound speed contours for this observed eddy.

The types of tracks for acoustic modeling initially considered are shown in Figure 4 in relation to a circularly symmetric eddy that matches the measured section. Track A leads from inside the eddy to outside; B cuts through the eddy; D is the same range as B but is solely in the Sargasso Sea; and E is the same range as A, but again solely within the Sargasso Sea. There was also a C profile (not shown) which went from the region of high sound speed gradients in the annulus of the eddy to the outside. Approximately 15 computer runs, using the 2D parabolic and the 3D parabolic equation models, were run on these tracks. Frequencies of interest were chosen; that is, frequencies anticipated to be used during the experiment, and the depths of the sources were varied. The results of these preliminary calculations are discussed below.

The first calculations were made to estimate the energy distribution and intensity perturbations caused by the eddy. An A and E type track are shown in Figure 5 for a source frequency of 230 Hz and a depth of 700 meters. Intensity versus depth and range is plotted for the two cases, where the dark portions indicate strong or high acoustic intensity. The depth distribution of energy is changed significantly by the presence of the eddy, especially for propagation starting within the eddy where the energy is constrained to a smaller portion of the sound channel than in the case for propagation in the absence of the eddy. Thus, in Figure 5 a number of paths that are normally steep RSR paths have been converted to much shallower angle RRR paths for propagation. Figure 6 is a second example again showing intensity versus range and depth for two cases, B and D type, of propagation completely through an eddy compared with unperturbed propagation in the Sargasso Sea. The source frequency is 88.8 Hz and source depth is 130 meters, and the eddy starts 150 kilometers range from the source. The energy propagating from the source strictly in the Sargasso Sea provides good ensonification at shallow depths due to a surface sound channel. This energy, as it goes into the eddy, is ducted downward and the effect of a surface sound channel with good ensonification ceases. In addition to overview characteristics such as seen in these figures, detail computations were made on several features of the acoustic propagation, in order to provide assurance that the median transmission loss would permit a signal level sufficiently high to monitor on a single array hydrophone. This involved a series of runs to select the depth at which potential substantial changes in transmission levels due to the presence of an eddy could be acoustically observed. In order to estimate these changes in transmission loss for the no eddy versus eddy case, the median value of the transmission loss was computed over a range interval approximately 80 kilometers broad, centered on the ranges of interest. In Figure 7 the difference in this median transmission loss was plotted as a function of receiver depth. For the cases of 230 Hz at 700 meters source depth and 88 Hz at 130 meters source depth, while there are differences of

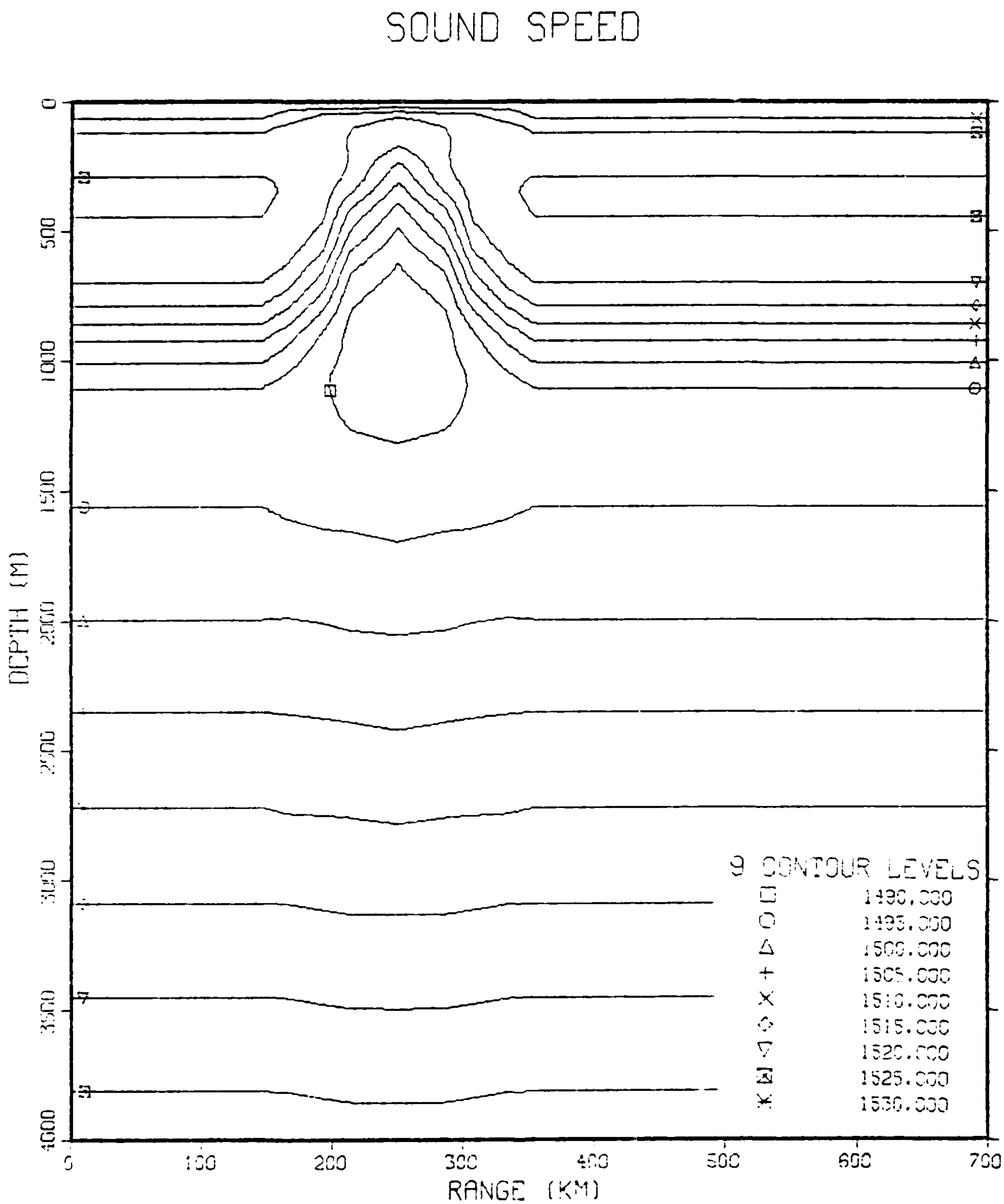

Fig. 3 - Sound Speed Contours of a Section of the Eddy Used in the Acoustic Modeling.

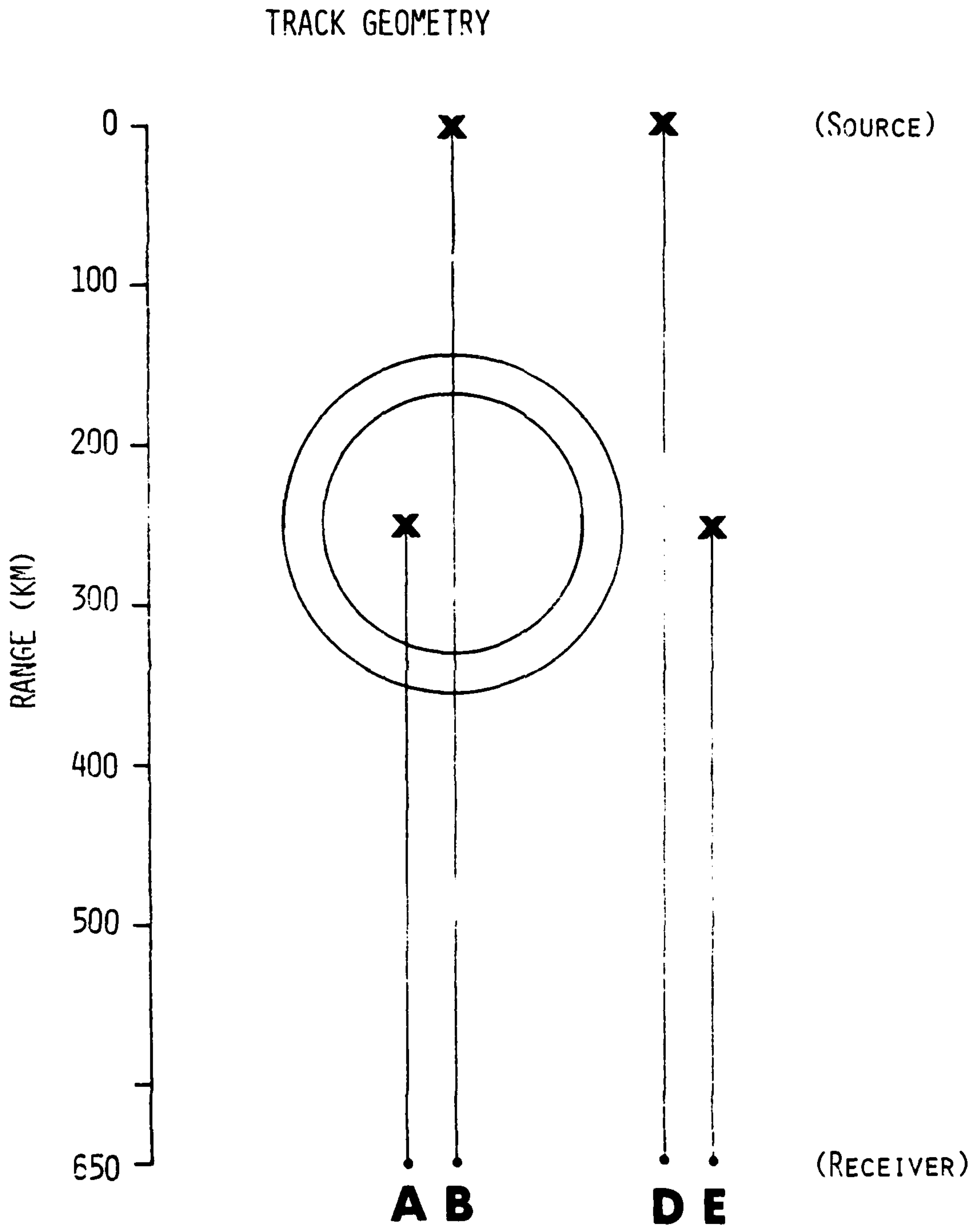

Fig. 4 - The Types of Propagation Tracks Used in the Acoustic Modeling.

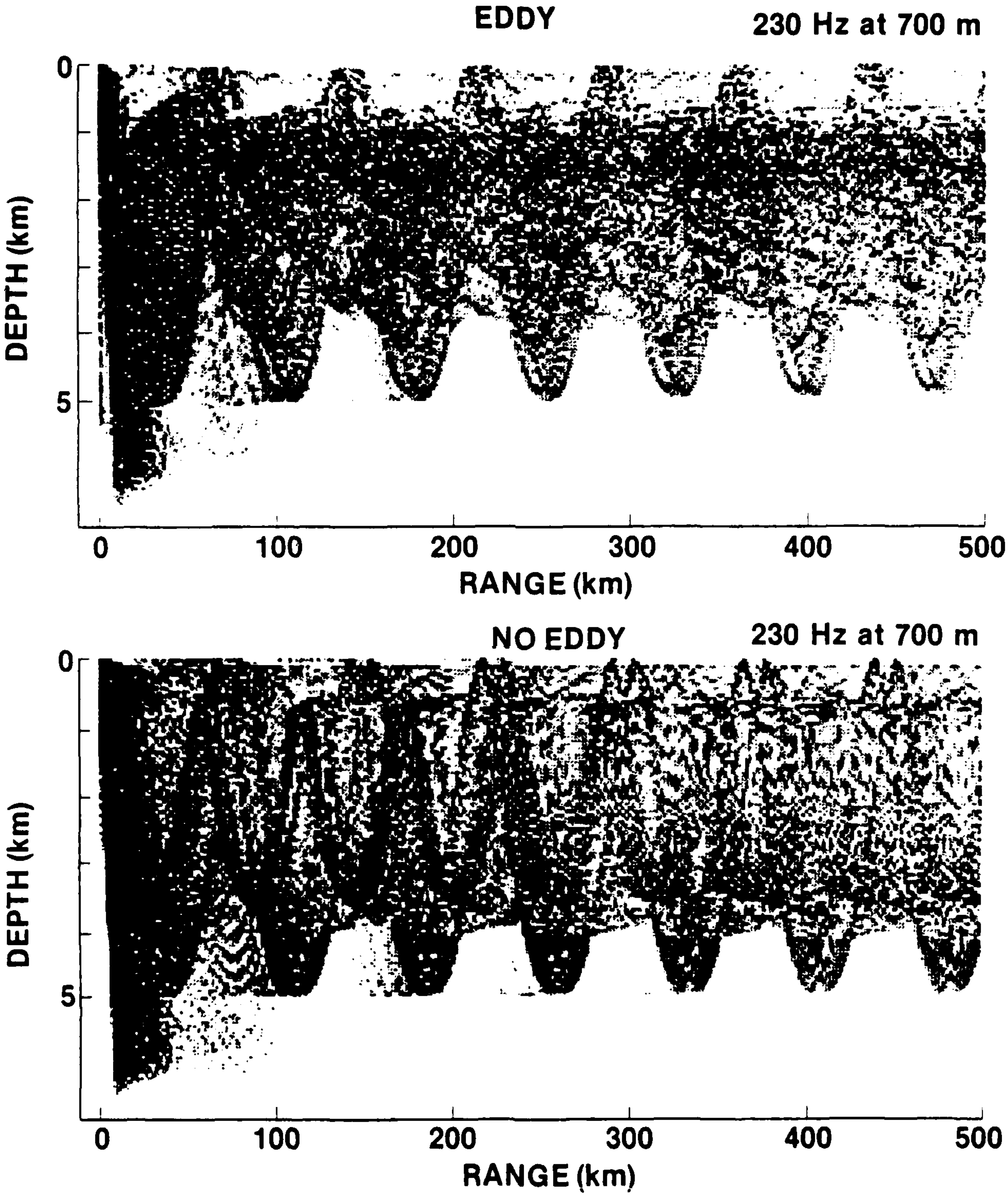

Fig. 5 - Intensity Shade Plots Comparing Propagation Along Tracks A and E for a 230 Hz Source at a Depth of 700 M.

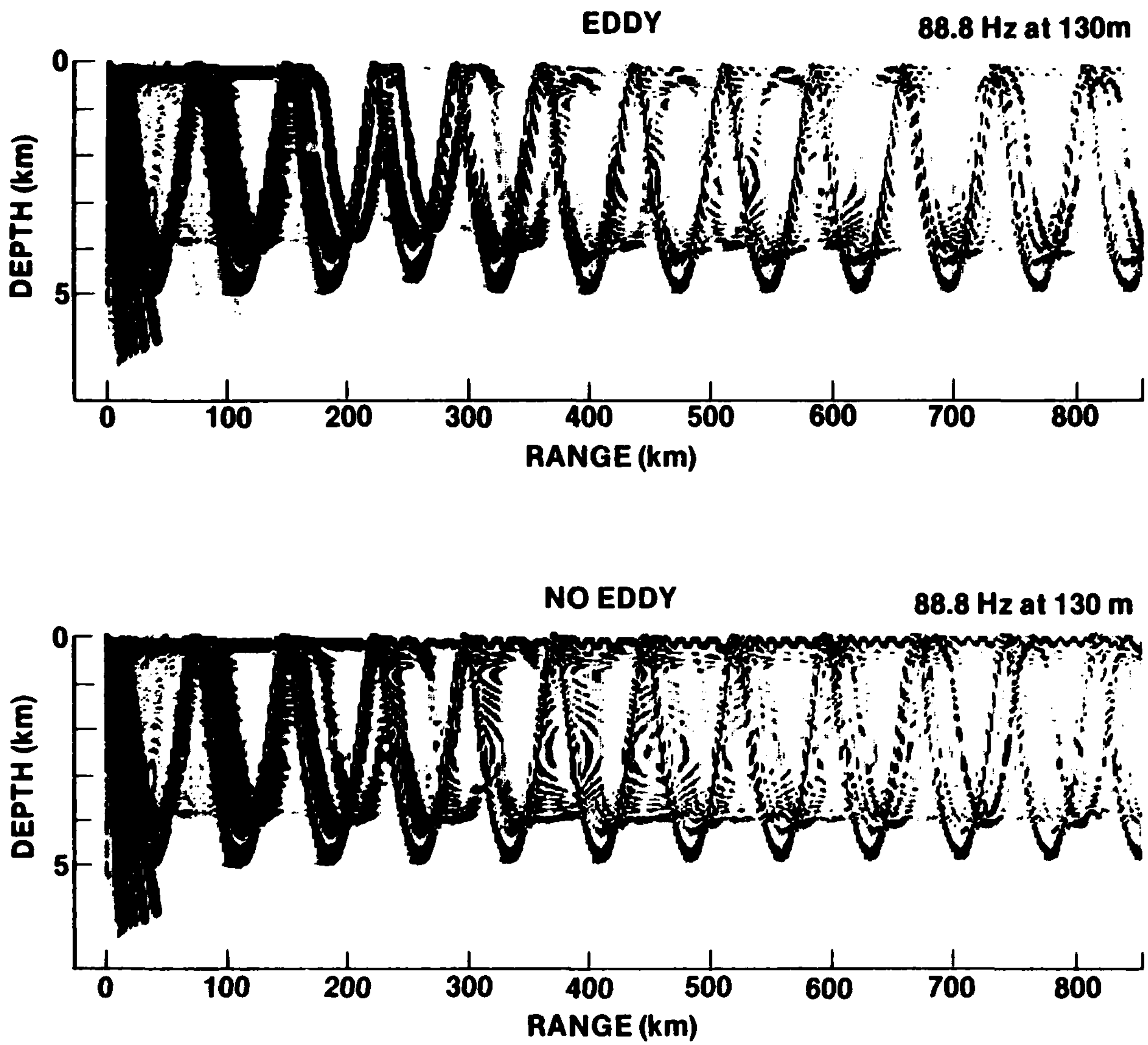

Fig. 6 - Intensity Shade Plots Comparing Propagation Along Tracks B and D for an 88.8 Hz Source at a Depth of 130 M.

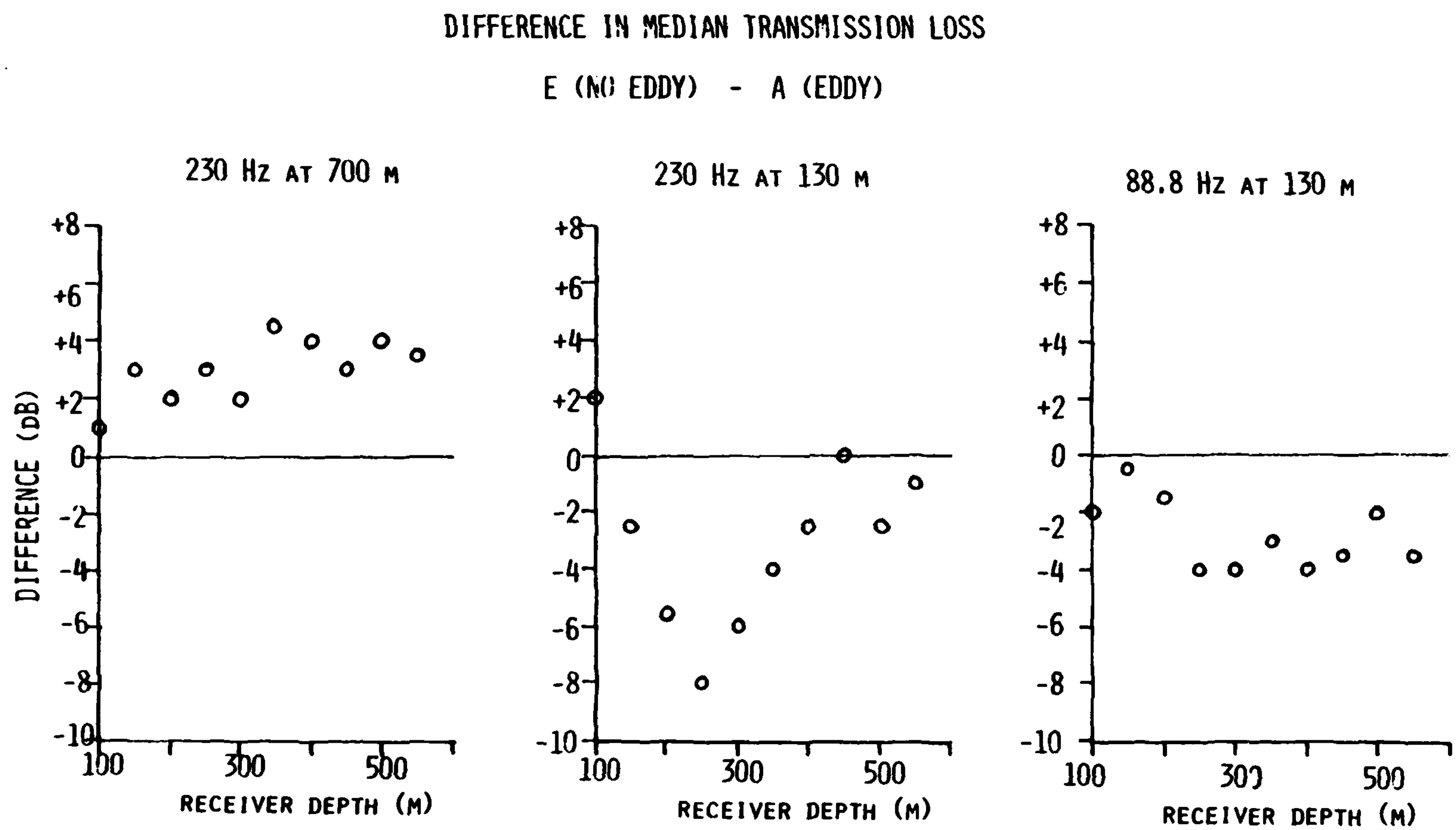

Fig. 7 - Difference in Median Transmission Loss for Propagation Along Track E (No Eddy) and Track A (Source in Eddy) for Three Frequency - Source Depth Combinations as a Function of Receiver Depth.

order 2-4 dB between the received energy at a number of depths in the eddy versus no eddy case, there was no preferential receiver depth. However, for the case of 230 Hz at 130 meters there is a preferential depth located around 200-250 meters receiver depth, where a 6-8 dB difference in the median transmission loss values of the eddy versus no eddy case is estimated.

Additional measures of acoustic propagation and the lower bound surveillance system performance effects were calculated. These included the array signal gain, the array angular resolving powers exhibited by the 3 dB width, and the apparent bearing of the source. In the first runs of the model we chose a perfectly straight horizontal receiver broadside to the propagation, to minimize multipath and eliminate deformation effects. The estimates utilized the three dimensional parabolic program and an axially symmetric and smooth sound speed structure, a section of which is plotted in Figure 3. These calculations show deterministic (environment totally known and regular) two-point spatial results, that would result from refraction and multipath interference by a mesoscale structure. This type calculation most closely approximates the bias or departure in aperture performance that would be expected in a corresponding measured ensemble average through such a dynamic feature. The results showed, as expected, measurable but minor effects due to horizontal refraction. While more detailed sampling of the candidate eddy may increase the lateral gradients, and the consequent mean observed results, these first calculations support the thesis of relating observable array effects to stochastic velocity variations expected in the mesoscale structure peripheries. For example, Figure 8 shows the small regular bearing angle deviation expected to be observed by an array looking out of (or through) an eddy. In this plot, which is angle versus range, the energy as it enters the cold eddy is refracted towards the region of small sound speeds. This causes a slight target apparent bearing wander of the order of .3 degree. As the array is positioned outside of and behind the eddy at progressively longer ranges, residual bearing deflections remain but the general tendency is to return to the actual bearing.

Since deviations of this magnitude and their regularity are observable, with accurately positioned farfield sources as bearing references, rapid fluctuations and beam spreading potentially observable during occultation, may be apparent. The 150 km size of these mesoscale structures should also allow resolution of that part of the eddy producing exceptional effects. That is, the annulus of an eddy, where the horizontal sound speed gradient is highest, also has the most intense turbulent mixing as well as potential for acoustic scattering.

An operational problem that affects observed array resolution is tilt, typically on the order of 2-4 degrees. To estimate the effects of multipath interference, which will change depending upon whether the source is inside or outside the eddy, the model was run using a straight receiver, but tilted at various degrees. The degradations due to multipath interference alone for a 4° tilt are small for the MF array at 230 Hz, of the order of 1 or 2 dB. As a result of these calculations and the transmission loss results, the array is being balanced for a depth of 250 meters, and the magnitudes of the average deterministic effects are considered acceptable.

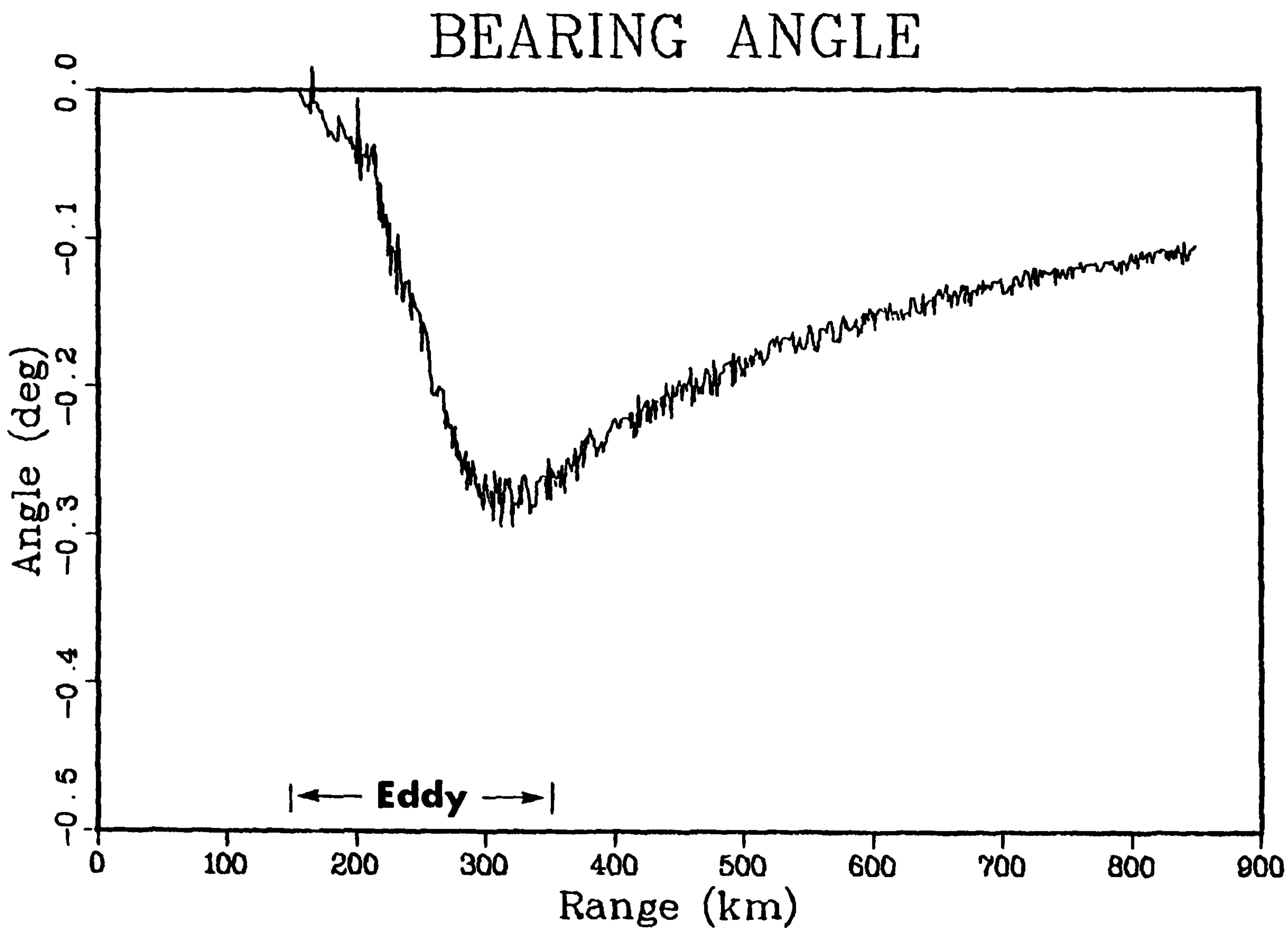

Fig. 8 - Target (Source) Bearing Angle as a Function of Range of the Receiver from the Source.

MEASUREMENTS OF THE EDDY

The present state of knowledge of the eddy to be investigated during the intensive June phase of the FREDDEX operation consists of several AXBT surveys and data obtained from a satellite-tracked buoy which was placed in the eddy during March air OPs by NAVOCEANO. Figure 9 shows the movement of the center based on the buoy data. Also shown are locations of the center determined from AXBT surveys. The data indicates a rather erratic path with periods of apparently rapid motion.

Figure 10 shows the thermal structure of the eddy at a 300 m depth level. This figure is based on AXBT measurements made during 14 and 16 May. A strong temperature contrast of 7°C exists between the eddy center and the exterior. An interesting feature is the shape of the isotherms which indicate the possibility of a wave-like disturbance to the overall eddy pattern. Such thermal structure will be of major concern during the ship operation in June, and subsequent acoustic modeling.

The thermal structure in the mixed layer above the eddy is shown in Figure 11. The structure is apparently much more complex than the deeper thermal structure at 300 m. It should be stressed that the exact isotherms drawn in this figure are rather tentative because other possible characterizations of the data are possible. In any event the data suggests the existence of various "pools" of water in the vicinity of the eddy across which maximum temperature contrast of some 3°C exists. Why they are present and their dynamic relationship to the deeper structure is a question of research interest to the physical oceanography of the eddy. Such structure mav also show up in satellite imagery during the course of the FREDDEX operation.

Finally, Figure 12 is a schematic of the nature of the ship tracks during which extensive XBT measurements will be made. Plans call for three such "pinwheel" circuits during the at-sea phase of FREDDEX. The results of these measurements should be the most extensive data ever collected on the three dimensional thermal structure of a Gulf Stream eddy and its changes during a month time interval.

OBJECTIVES (Partial Listing)

High Resolution Array Measurements

The objective is to develop a capability to predict temporal and spatial variations of the acoustic field for long-range, low-frequency, high-resolution underwater surveillance arrays.

The coherent summation of energy over large horizontal apertures is impaired by random scattering in the medium, deformations in the array, and multipath interference due to array tilt. FREDDEX will help determine the extent to which the presence of an eddy contributes to scattering. Array deformations will be measured by aircraft shots and towed sources to separate this mechanism. Moored

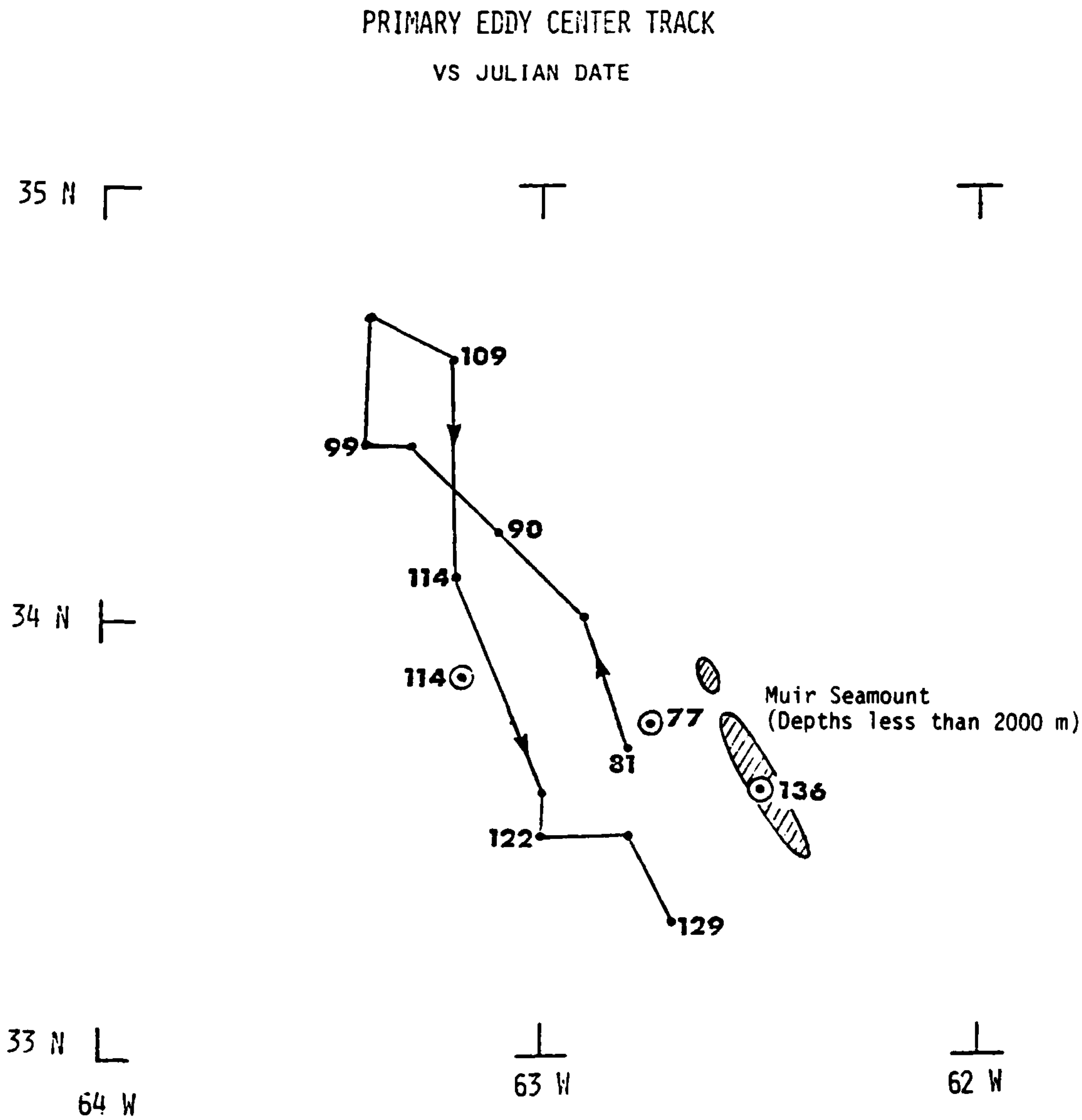

Fig. 9 - Position of Primary Eddy Center as a Function of Julian Day Based on AXBT's (⊙) and on Buoy Transmissions (·).

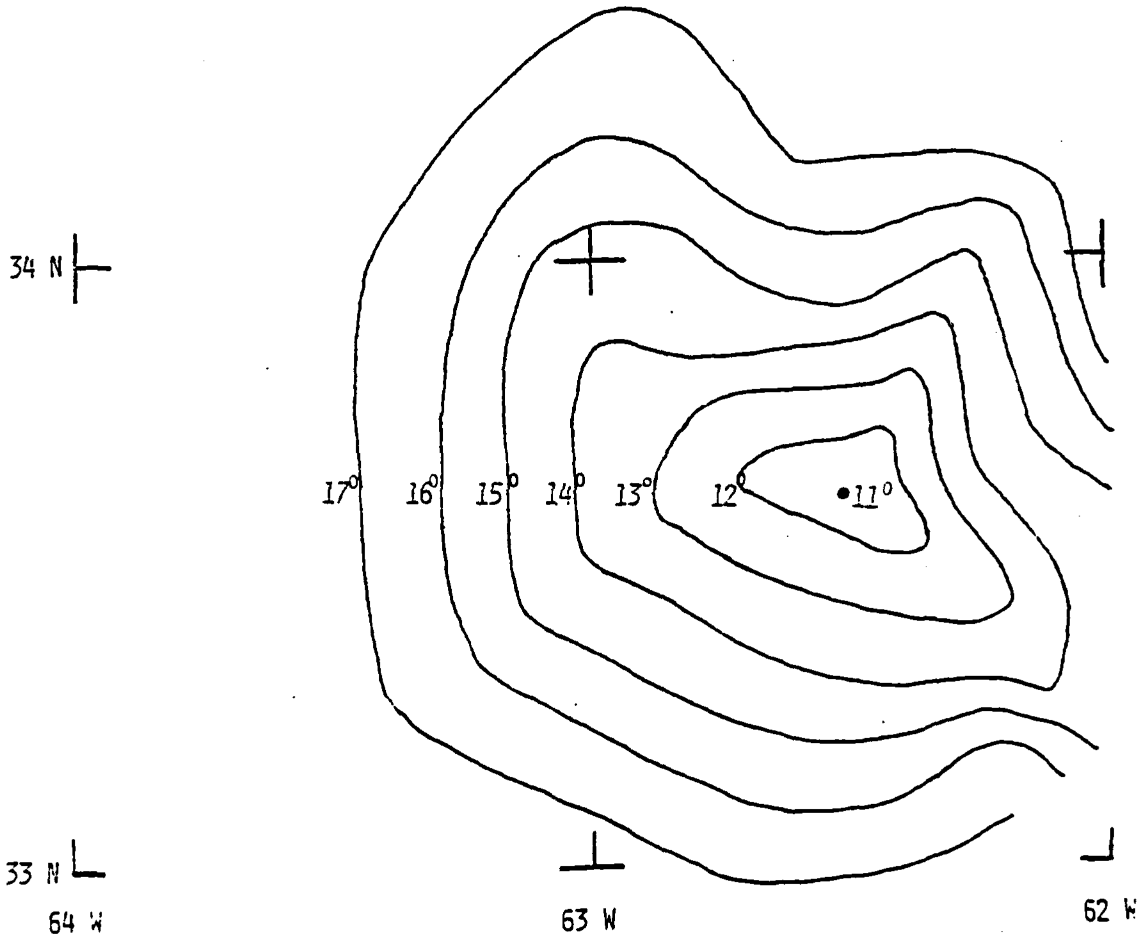

Fig. 10 - Isotherms of the Primary Eddy at 300 M Depth Based on AXBT Data of 14 and 16 May.

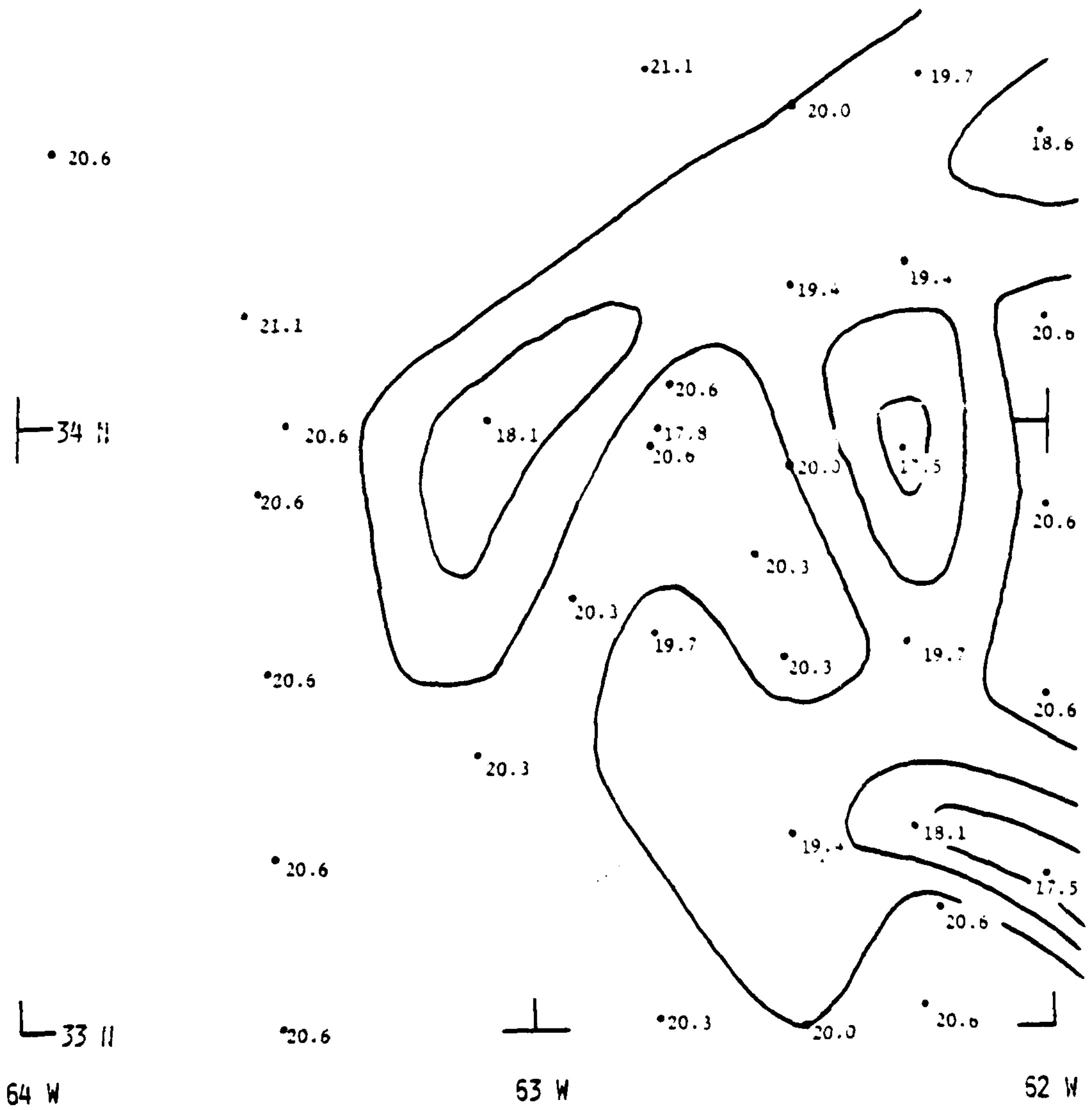

Fig. 11 - Apparent Thermal Structure in the Mixed Layer Based on AXBT Data of 14 and 16 May.

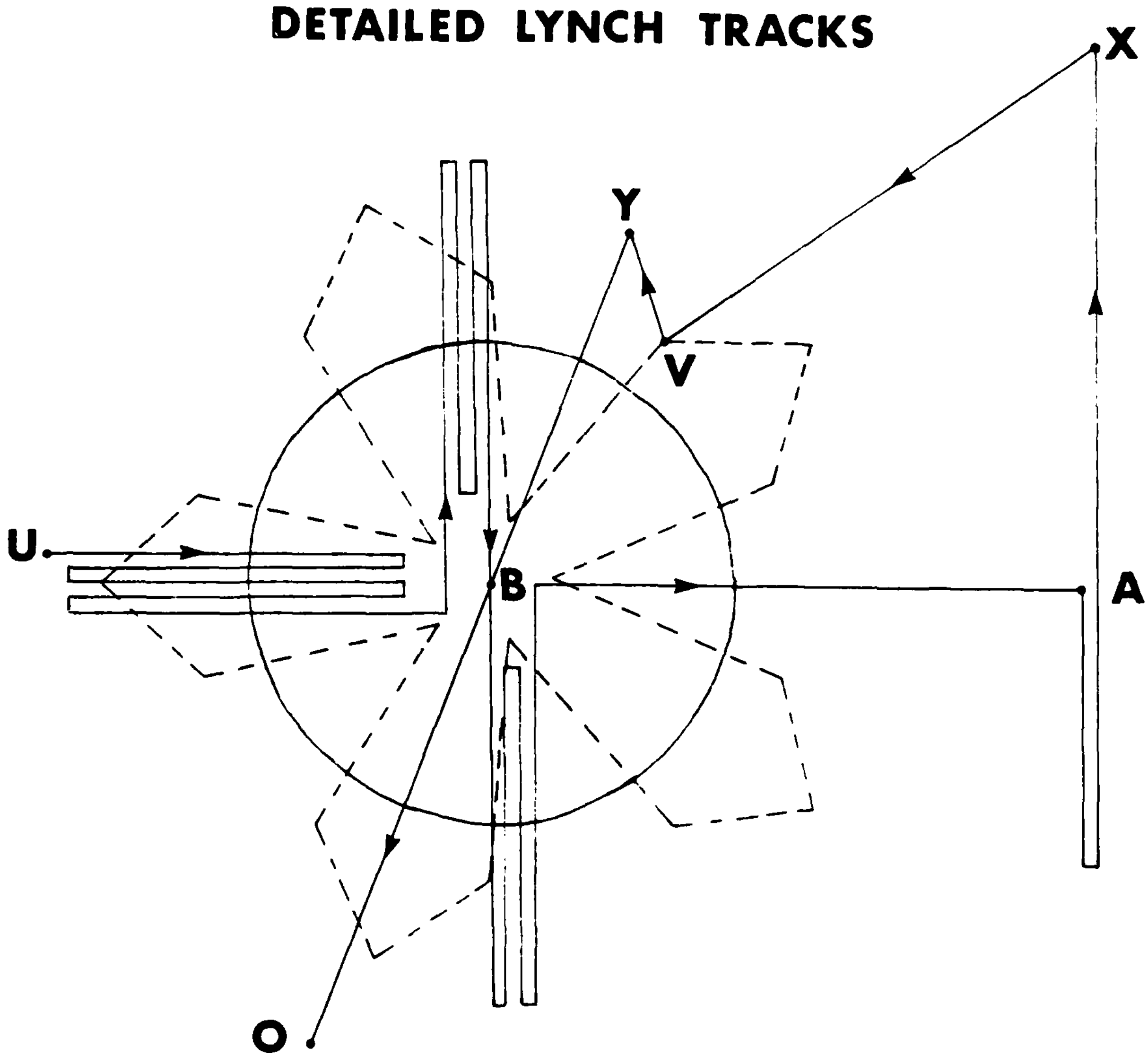

Fig. 12 - USNS LYNCH Tracks Showing How the Source Will be Towed in the Eddy (Solid Line) and the Pinwheel Survey Pattern (Dashed Line).

continuous narrow band acoustic sources will be used for major propagation influences by an eddy-type feature and to provide data for the assessment of two new techniques to remove array deformation effects. The new techniques are complex subaperture grooming and cross-phase (between multiple sources) correlation along the array. The sub-experiments are being conducted to test the feasibility of correcting for deformations in real time in a covert passive fashion.

Oceanographic Measurements

The Spatial Variability project is concerned with a study of those physical processes responsible for spatial variability in the ocean and the exploitation of such knowledge for underwater acoustics. Of recent concern is the potential utility of satellite data, and other remotely sensed data, which provide information on surface properties, especially the extent to which surface data can be used to deduce information on the deeper ocean structure. An important step in this downward extrapolation of surface information is the determination of the relationship of the surface properties to the mixed layer.

The fundamental objective of the at-sea measurement program is to obtain detailed information on the eddy structure and evolution of that structure as well as the survey techniques required to adequately sample the structure. Since the relation of the eddy structure to satellite inferred data is to be addressed, it is necessary to sample the eddy structure with a high density over the horizontal extent of the eddy.

Characteristics of the mixed layer above the eddy are also an important aspect of the measurement program. It is also desired to monitor the translational process of the eddy over a long period of time through use of satellite data with ship studies carried out during the at-sea phase of the experiment. Specific objectives of this measurement program are listed below.

1) Large scale structure of the eddy and its change over several rotation periods.

2) Variability in the region surrounding the eddy.

3) Presence of surface fronts and spatial variability in the mixed layer.

4) Relationship of surface variability to satellite data.

5) Relationship of surface variability to deeper ocean structure.

6) Obtain environmental data for related acoustics experiment.

Stochastic Acoustic Propagation

In order to develop predictive capabilities it is necessary to test numerical models in diverse scenarios. Models of acoustic propagation including stochastic terms are currently under development and are being implemented on a computer. Of interest in testing these models is a region containing an eddy as the presence of an eddy may increase the stochastic effects of the environment. The results of FREDDEX will be used to evaluate and upgrade the multipoint propagation model.

Ambient Noise

The objective is to statistically characterize the beam noise frequency-azimuth surface to provide a basis for assessing both towed array surveillance capability and beam noise predictive capability. The statistics of the beam noise surface will be obtained over a 30-60 Hz frequency band and the full, 180 degree azimuthal surface. These statistics include the spectral line density, signal-to-noise distributions, and percentile surfaces of both the total and the background noise power.

Remote Sensing

Features such as an eddy have several different kinds of scars. A cold eddy leaves a surface temperature scar when newly formed. As it ages, decays, it also increases in its depth. As it moves away from the surface, the surface temperature scar can become obliterated. The remote sensing investigators are interested in measuring the surface temperature scar and determining how long this feature will be present for an eddy. Another aspect of the eddy due to circulatory motion is that it changes the surface currents. The over-the-horizon radar investigators are interested in determining whether they can remotely sense the change in surface currents associated with the eddy. They have an advantage over the current satellite community in that cloud cover does not obscure their observations, and that they will be able to provide continuous real time area (not strip) coverage provided the methods are successful.

ACKNOWLEDGEMENTS

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APPENDIX A - Operation Plan for NRL Cruise 79-16-03 USNS HAYES

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USNS HAYES CRUISE 79-16-03 - PROJECT FREDDEX

1. OBJECTIVE

The objective of USNS HAYES during FREDDEX is to tow the Mid-Frequency Array (MFA) and record a variety of acoustic information:

(a) cw signals from moored and towed acoustic sources through a strong thermal feature (eddy);
(b) shipping noise over a wide azimuthal sector;
(c) nearfield SUS for array deformation; and
(d) nearfield SUS and larger explosives for surface backscattering and basin reverberation.

2. OPERATING AREAS

The general Operation's Plan for USNS HAYES during June, 1979 is given below with coordinates corresponding to the letter designations found in Table I. The details are found in TABLE II. For completeness, the detailed schedule of LYNCH is also included in TABLE III. The area clearences for towing MFA and expending ordinance are being handled by Code 8004 at NRL.

Location	Time Period (Zulu)	Descriptions
Cheatham	04/1200	COMEX
W	05/1030 - 05/1430	Launch balloons
C	06/1230 - 06/1730	Deploy Source
A	08/0330 - 08/0830	Deploy Sources
B	08/1600 - 08/2100	Deploy Sources
D to E	09/1030 - 17/2100	Tow MFA
DD to B	19/1130 - 21/0100	Tow MFA and retrieve sources
A	22/1000 - 22/2000	Retrieve sources
C	24/0830 - 24/1330	Retrieve source
Cheatham	25/2330	FINEX

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3. COMMUNICATIONS

SCICOMNET for NRL Cruise 79-16-03 will be as follows:

Unit	Call Sign
USNS HAYES	Researcher 55
USNS LYNCH	Researcher 66
R/V ENDEAVOR	Endeavor
NRL Aircraft	Researcher 674
NAVOCEANO Aircraft	Navy 500
NRL	Researcher LIMA
L. Galli (NRL 8004)	Researcher GOLF
NASA Wallops Flight Center	Wallops Plot
Tudor Hill, Bermuda	Ten Pin

HF SSB Frequency

Primary	7690.0 kHz
Secondary	4482.5 kHz
Terciery	11670.0 kHz
Quaternary	8291.1 kHz
NASA Wallops Flight Center	3030.0 kHz

UHF Frequency

Primary	328.2 MHz

(a) SCICOMNET communications for ship to NRL traffic will be HF SSB during the period 4 - 25 June 1979 at 1400Z and 2000Z Monday through Friday.

(b) SCICOMNET communications ship to ship and ship to Tudor Hill will be seven days a week on the same frequencies and at the same times.

(c) SCICOMNET communications between ships and aircraft normally will be HF SSB. If UHF communication becomes advantageous during short range operations, then 328.2 MHz will be used.

(d) USNS HAYES will initiate the scheduled radio checks at 1400Z and 2000Z. HAYES will talk to the various parties in the following order: USNS LYNCH, R/V ENDEAVOR, TUDOR HILL and NRL.

(e) Communications equipment will be operated by qualified scientific radio operators only under the direction of the SSOB, and all applicable procedures will be followed.

(f) Specific items of communication include:

i. Daily progress reports from USNS LYNCH and R/V ENDEAVOR to USNS HAYES at 0400Z.

ii. Suggested change of source implantation position at B from Tudor Hill to USNS HAYES 08/1300Z.

iii. Updated eddy center position after each environmental flight from NRL to all three ships.

(g) MARISAT will be used only at the discretion of the SSOB. The teletype mode will normally be used to save money.

(h) USNS LYNCH and USNS HAYES will send situation reports to each other via Naval Message with copies to NRL, Tudor Hill and NAVOCEANO on a daily basis.

4. NAVIGATION

(a) Navigation will be under the direction of the Scientific Navigator. Close adherence to the desired track will be maintained on a continual basis utilizing Loran-C. Fixes will be logged and plotted every 15 minutes and whenever there is a course or speed change. Fixes will also be logged for each XBT drop and each source deployment.

(b) Satellite fixes will be logged when received and will be checked to insure that the Loran-C receiver is tracking properly.

(c) Code 8004 Navigation Data logs will be provided and will be filled out in accordance with instructions provided by the Scientific Navigator.

(d) Navigational charts for the operational areas will be provided by Code 8004.

5. SAFETY PRACTICES

During the conduct of the experiment, both at sea and on land the SSOB will be the Safety Officer of the scientific party. He will supplement the normal safety practices of the ship's Captain and crew in activities where the scientific party is involved. The following safety practices will be followed during the experiment:

(a) Pre-sail Inspection - The SSOB will inspect all areas of the ship where the scientific party will be working to locate and eliminate all work hazards. He will solicit advice from the scientific party as to any hazard that may exist in their particular area of activity and institute action to remove or minimize them.

(b) Loading and Off-loading Coordinator - During the loading and off-loading of scientific equipment in port, Code 8004 will designate a coordinator to supervise these operations and to act for the SSOB in all matters concerning safety practices.

(c) Launching and Retrieval of Equipment at Sea - Prior to the launching and retrieval of equipment at sea, the SSOB will hold a meeting with the senior NRL 8004 representative (Deployment Supervisor) and members of the scientific team. At the meeting, a review of all launching/ retrieval procedures will be made and specific duties will be assigned to each team member. During actual launching/retrieval operations, all members of the scientific party not assigned to the team are to stay clear of the work area. The SSOB and the Deployment Supervisor will be on deck during all launching and retrieval operations to insure all safety procedures are followed.

6. TIME KEEPING

All events will be timed accoring to Greenwich Mean Time (GMT) and all logs and records will be annotated with GMT.

The time code generator (TCG) will be synchronized with WWV at the beginning of the operation and checked for drift each morning and evening. The TCG will be realigned whenever the drift exceeds 200 ms and this will be recorded on a separate TCG log to be kept near the device.

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7. PERSONNEL

SSOB - The Senior Scientist on Board is responsible for all administrative matters relating to the scientific crew on USNS HAYES (e.g. overtime approval, berthing,...). He is the primary interface between the scientific staff and the ship's Master and officers. He suggests and consults with the TDO on technical operational details and reserves veto authority on major decisions. In addition, he has the added responsibility of coordinating the entire FREDDEX operation through radio and MARISAT communication with LYNCH, ENDEAVOR, NRL and Tudor Hill.

TDO - The Technical Director of Operations is responsible for the technical details of the scientific work including organizing shifts and describing the duties to be performed at each watch station. He is also responsible for decisions regarding contingencies and modifications to this Operation's Plan, necessitated by unforseen circumstances, insofar as they relate to USNS HAYES. Major modifications will be discussed with the SSOB for comments.

Normal working assignments will be made by the TDO and will be consistent with the training and qualifications of personnel; however, all personnel are subject to collateral duties if operating requirements so warrant and it is deemed necessary by the senior scientist. Operations will be conducted 24 hours a day. Overtime will be worked only as necessary, and approved by the SSOB. All personnel should be ready to cooperate on all launchings and retrievals of mechanical equipment if it becomes necessary. No overtime will be worked in port or on transits unless deemed necessary by the TDO.

The following personnel will participate in USNS HAYES Cruise 79-16-03:

NAME	ORGANIZATION	SPECIALTY
Dr. William B. Moseley	(NRL 8160)	FREDDEX Coordinator and SSOB
Mr. Donald R. Del Balzo	(NRL 8160)	Technical Director of Operations (TDO)
Mr. Dennis M. Dundore	(NRL 8160)	Research Scientist
Mr. Steve Schechter	(NRL 8160)	Research Scientist
Mr. James M. Griffin	(NRL 8160)	Research Scientist
Mr. Randy Bish	(NRL 8160)	Electronics Technician
Mr. John Fritz	(NRL 8160)	Software Engineer
Mr. Jason H. Taylor	(NRL 8004)	Deployment Supervisor
Mr. Ralph A. Gallatin	(NRL 8004)	Mechanical Technician
Mr. Horst W. Koster	(NRL 8004)	Electronics Technician
Mr. Anthony Zuccaro	(NRL 8004)	Scientific Navigator
Mr. Lee M. Huston	(NRL 8004)	Electronics Technician
Mr. Gordon Cooke	(NOSC 7112)	Array Operations Expert
Mr. Lawrence Dempsey	(NADC 4054)	Balloon Project Engineer
Mr. Harold Dewhirst	(NADC 4054)	Mechanical Engineer
Mr. Benjamin Birchfield	(NADC 4054)	Balloon Operations Expert
Mr. Warren Rogers	(NRL 2603)	Director of Photography
Mr. James E. Taylor	(NPC)	Photographic Crew Chief
Mr. Henry A. Champagne	(NPC)	Cameraman
Mr. Allen W. Harrison	(NPC)	Soundman

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8. EQUIPMENT (Partial List)

(a) NRL-8160 (8 racks)
11/34 computer system (128 A/D chs & 4 small array processors)
MAC patch panel
4 disk drives & a 2 MWord mass memory
3 digital tape drives (2 1600 bpi, 1 800 bpi)
SPS-81 array processor
Nicolet spectrum analyzer (444) & data logger (144)
Analog processing system (including 64 ch Sabre V tape recorder)
4 acoustic sound sources (224, 227, 230, 350 Hz)
Time code generater/reader

(b) NRL-8004
LORAN C and SAT NAV
HF (SSB) and UHF radio capability plus MARISAT with teletype
XBT and PDR systems
Shot monitoring system (1 rack) including shot hydrophone
Ambient noise type hydrophone to monitor source emission
2 quarter-wave receivers
6 AMF acoustic release/transponders
2 deck unit acoustic release recall systems
1 large bottle of nitrogen
Remote speaker for 24-hour monitoring of radio and MARISAT
WWV receiver

(c) NRL-8140
Buoyancy floats & polypropylene line
6 radio beacon buoy transmitters (27 MHz)

(d) ARPA/PME-124
Mid-frequency array, tow cable and deck cable
Winch, power drive, winch control pedastal & level wind
Array power supply, line equalizers and NAS readout unit

(e) NOSC
Deck van with consumables and array support (7' x 12' x 7')

(f) APL- Johns Hopkins
Signal conditioning units

(g) NADC
10 balloons (each 2' x 2' x 5' boxed)
Launcher mechanism
60 helium bottles
Tracking electronics & antenna

(h) NORDA
162 Hz acoustic sound source

9. ENVIRONMENTAL SAMPLING

(a) Thermosalinograph - This will be run at all times between events H10 and H43. All XBT drops will be annotated along with the appropriate time.

(b) Precision depth recorder - The 3.5 kHz and 16 kHz PDRs will be run during events H11-H15 and H35-H43 and annotated with GMT at least every 4 hours.

(c) XBTs - 54-T5 and 139-T7 XBTs will be launched according to the table below. The thermosalinograph temperature reading will be transcribed onto the XBT record along with drop number, position, Greenwich time and USNS HAYES event number. In case of failure, T5s will not be repeated, but T7s will be repeated. USNS HAYES will slow to 5 knots during each T5 launch.

EVENT	SEQUENCE	DISTANCE BETWEEN LAUCHES (MI)
H10	T5, T7	0
*H11	T5, T7, T7, T7	25/6 *
H12	T5, T7	0
H13	T5, T7, T7, T7	6
H14	T5, T7	0
*H15	T5, T7, T7, T7	25/6 *
H17-H34	T5, T7, T7, T7	21 (every 6 hr)
*H35-H43	T5, T7, T7, T7	25/6 *
H44	T5, T7	0

* Decrease distance between launches to 6 miles whenever within 60 miles of the eddy center as defined by the navigator.

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10. MOORED SOURCE OPERATIONS

The source deployments are under the supervision of the Deployment Supervisor. An accurate navigational fix will be taken at the time of deployment and the source will be tracked during it's descent using the interrogation circuitry and transponder on the acoustic release. If time permits, once the unit is in place, USNS HAYES will maneuver to a point one mile from the source and deploy a standard noise-type hydrophone (sensitivity approx. -178 dB re Pa /v) to a depth of greater than 200 feet for 10 minutes of source level monitoring. Then, USNS HAYES will maneuver to a point 4 miles from the source and repeat the 10-minute level monitoring. During these periods, USNS HAYES should come to all stop to reduce propeller noise and ensure good signal to noise at the suspended hydrophone.

11. TOWED ARRAY OPERATIONS

In general, the Deployment Supervisor has overall responsibility for the mechanical and electrical integrity of the array including deployment, retrieval, maintenance, calibration of the non-acoustic sensors (NAS) and repairs to insure successful array operations. The Array Operations Expert is available for consultation and whatever assistence is required. During all array towing periods, USNS HAYES will run on auxiliary engines to reduce radiated noise.

12. BALLOON OPERATIONS

A total of 10 balloons will be launched during the exercise by personnel from NADC. Approximately 5 will be launched on 5 June and tracked by Wallops Island tracking equipment. The remaining balloons will be launched and tracked from HAYES at intermittant times during the exercise. Most of these launchings will occur during high speed transits to minimize possible interference with HAYES superstructure.

13. AIRPLANE OPERATIONS

(a) On 11 and 15 June, an NRL P3 airfraft (674) will rendezvous with USNS HAYES about 1400Z, begin flying a pattern and drop MK-64 and MK-83 SUS for array deformation measurements. Sonobuoy flares will be dropped as markers and repositioned when they are extinguished. The expected on-station time is 6 hours.

(b) There will be several other aircraft flights during the exercise devoted to environmental (AXBT) studies but none of these are expected to rendezvous with USNS HAYES. However, their results concerning the eddy center will be transferred to all three ships on the following day's regularly scheduled morning radio check. The expected flight dates are 7, 13 and 21 June for the NRL aircraft and 4, 5, 10, 12, 17, 19 and 25 June for the NAVOCEANO aircraft.

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14. EXPLOSIVE WORK

(a) Surface backscattering strength - Ten 1/2 - hour periods will be devoted to measuring surface backscattering strength using 20 Mk-94/Mls per period. These will be scheduled at 1500Z each of the 9 days during events H17 - H27 and once during event H37. The time can be modified with approval from the TDO.

(b) Basin reverberation - Ten 11-element explosive arrays will be dropped at intermittent periods during Events H17 - H27 during daylight hours at times deemed appropriate by the TDO in view of other processing.

(c) Reverberation suppression - 15 explosive line arrays and 5 omni-directional charges will be detonated to investigate suppression of bottom reverberation. Two 2-hour periods are required for this work. The specific times will be approved by the TDO.

(d) Vertical array shape - Eighteen Mk 64s will be dropped to determine the vertical deformation of the towed array. One Mk 64 (set for 60') will be dropped at 0100Z and 0900Z each day the array is in the water.

(e) Record keeping - A special log will be kept to indicate the sequence number, time, position and depth of each explosion. Every effort will be made to record the times to the nearest second, or better.

EXPLOSIVE LIST

Number	Weight (lbs.)	Depth (m)	SUS
200	5	610	Mk 94
10	15	1525	Mk 59-1A
5	25	1525	Mk 59-1A
15	50	1525	Mk 59-1A and Mk 94
42	0.1	244	Mk 64
18	0.1	18	Mk 64

15. PHOTOGRAPHIC WORK

A Navy photographic crew will participate in this cruise to make a movie about the FREDDEX operation and general sea-going activites on HAYES. This will be done a not-to-interfere basis and no scientific work will be redone for photographic purposes without approval from the TDO. The photographic crew will not hinder the scientific work while shooting all aspects of FREDDEX, including: source and array deployment and retrieval, balloon launching, explosive construction and deployment, aircraft and ship rendezvous, XBT operations, navigation, computer processing, etc.

TABLE I. FREDDEX Coordinates

POSITION	LAT	LONG
A	33 00	61 00
B	33 40	62 45
C	33 40	69 45
D	32 50	66 15
E	36 00	66 15
F	34 00	63 05
G	33 20	62 25
H	35 33	69 15
I	34 30	70 00
J	33 30	70 00
K	32 30	70 00
L	32 30	68 00
M	33 30	68 00
N	34 30	68 00
O	32 30	64 00
P	34 30	66 00
Q	32 30	66 00
R	34 00	69 00
S	37 32	71 45
T	34 15	69 00
U	33 40	64 00
V	34 30	62 45
W	37 20	73 30
X	35 00	61 00
Y	34 30	61 50
Z	39 00	68 00
AA	32 00	61 00
BB	33 20	62 45
CC	33 40	65 30
DD	33 40	66 15
EE	35 05	66 15
FF	34 00	64 00
GG	33 20	64 00
HH	34 20	64 00
KK	33 40	61 30
SS	39 45	70 45
WW	37 20	74 30
Newport	41 30	71 30
Narrangansett	41 30	71 30
Bermuda	32 20	64 45
Cape Henry	37 00	76 00

TABLE II. DETAILED USNS HAYES SCHEDULE FOR FREEDEX

EVENT	START TIME(Z)	DESCRIPTION	DURATION (HR)	DISTANCE (MI)	SPEED (KT)
H01	04/1200	Transit to Yorktown	1.0		
H02	1300	Load explosives	2.0		
H03	1500	Transit to Crainy Is.	4.0		
H04	1900	Load fuel	5.0		
H05	05/0001	Transit to Cape Henry	3.0		
H06	0300	Transit to WW	7.5	74	10
H07	1030	Transit to W & launch balloons	4.0	48	12
H08	1430	Transit to C	22.0	286	13
H09	06/1230	Deploy 230 Hz source	5.0		
H10	1730	Transit to KK	30.5	412	13.5
H11	08/0001	Transit to A	3.5	47	13.5
H12	0330	Deploy 224, 350 Hz sources	5.0		
H13	0830	Transit to B	7.5	96	13
H14	1600	Deploy 227, 162 Hz sources	5.0		
H15	2100	Transit to DD	13.5	175	13
H16	09/1030	Deploy MFA at DD	10.5		
H17	2100	Tow MFA on 000°T	40.0	140	3.5
H18	11/1300	Turn at E	2.0		
H19	1500	Tow MFA on 180°T	52.5	190	3.5
H20	13/1930	Turn at D	2.0		
H21	2130	Tow MFA on 000°T	38.5	135	3.5
H22	15/1200	Turn at EE	2.0		
H23	1400	Tow MFA on 180°T	38.5	135	3.5
H24	17/0430	Turn at D	2.0		
H25	0630	Tow MFA on 000°T	14.5	50	3.5
H26	2100	Turn at DD	1.0		
H27	2200	Tow MFA on 090°T	10.5	37	3.5
H28	18/0830	Retrieve MFA at CC	4.5		
H29	1300	Transit to HH	7.0	85	12
H30	2000	Deploy MFA	8.0		
H31	19/0400	Tow MFA on 000°T	5.5	20	3.5
H32	0930	Rendezvous w/ LYNCH at GG	0.0		
H33	0930	Tow MFA to FF	11.5	20	3.5
H34	2100	Change course at FF	1.0		
H35	2200	Tow MFA on 090° to F	13.0	46	3.5
H36	20/1100	Change course at F	1.0		
H37	1200	Tow MFA toward G	15.0	52	3.5
H38	21/0200	Turn 180° at G	2.0		
H39	0400	Tow MFA toward B	7.5	26	3.5
H40	1130	Retrieve MFA & 2 sources at B	14.5		
H41	22/0200	Transit to A	8.0	96	12
H42	1000	Retrieve 2 sources at A	10.0		
H43	2000	Transit to C	36.5	440	12
H44	24/0830	Retrieve source at C	5.0		
H45	1330	Transit to Cape Henry	28.0	365	13
H46	25/1730	Transit to Cheatham	6.0		
H47	2330	Arrive Cheatham			

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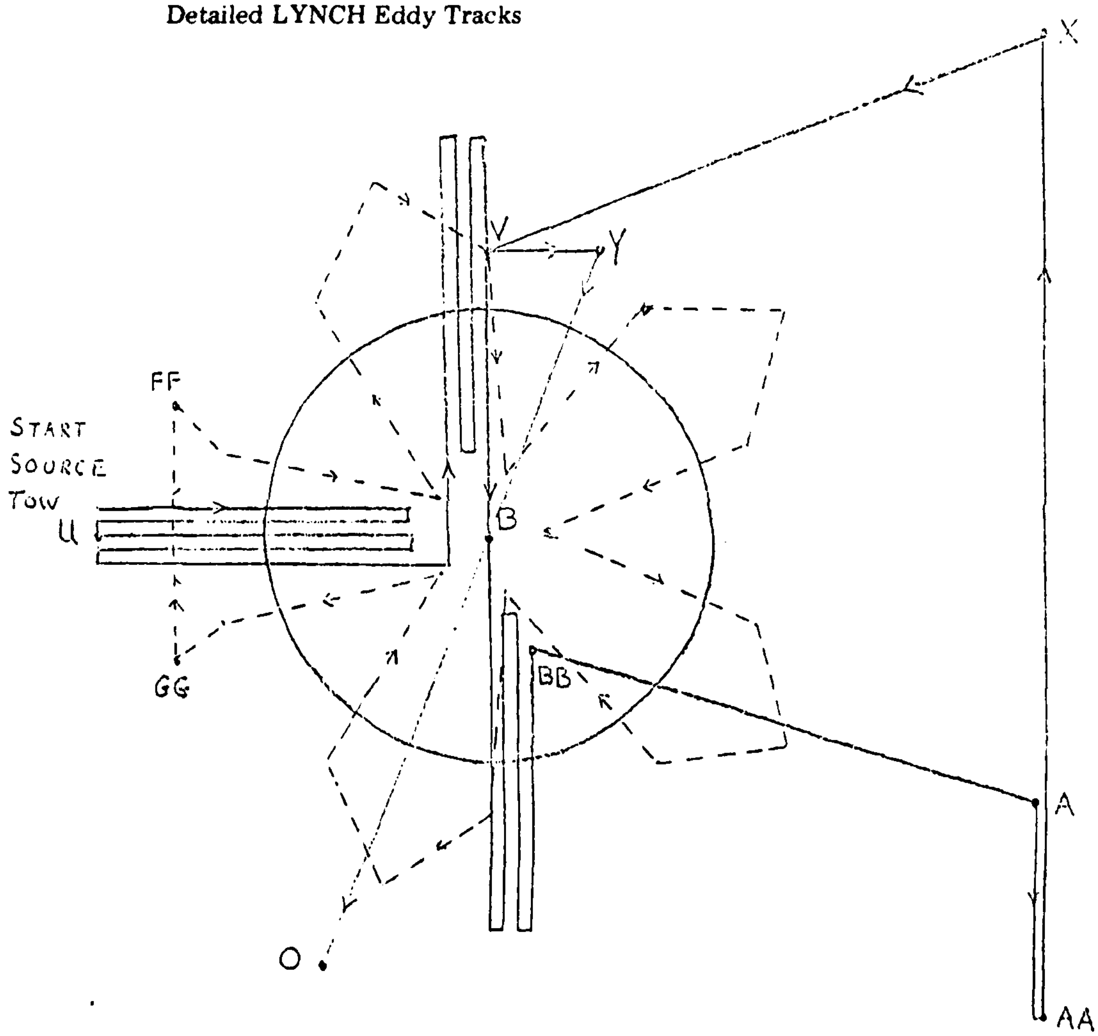
TABLE III. DETAILED LYNCH SCHEDULE FOR FREDDEX

EVENT	START TIME (Z)	DESCRIPTION	DURATION (HR)	SOURCE DEPTH (M)	DISTANCE (MI)	SPEED (KT)
L01	03/1030	Transit to S	26.4	-	238	9
L02	04/1300	Deploy HLF at S	1.0	-	-	-
L03	1400	Tow HLF to H	2.31	30	169	8
L04	05/1130	Change course; tow to U	31.4	30	283	9
L05	06/1900	Pinwheel eddy sampling	74.0	30-150	640	8.6
L06	09/2100	Acoustic pattern in eddy	8.0	130	56	7
L07	10/0500		8.0	130	56	7
L08	1300		8.0	50	56	7
L09	2100		8.0	50	56	7
L10	11/0500	Tow U to B	10.0	130	62	6.2
L11	1500		10.0	130	70	7
L12	12/0100		8.0	50	56	7
L13	0900		8.0	50	56	7
L14	1700		20.0	130	140	7
L15	13/1300		8.0	50	56	7
L16	2100		8.0	50	56	7
L17	14/0500		10.0	130	70	7
L18	1500	Tow BB to A	13.0	130	90	7
L19	15/0400	Tow A to AA	8.5	130	60	7
L20	1230	Tow AA to X	21.5	130	150	7
L21	16/1000	Transit to V	11.5	130	91	7
L22	2130	Start pinwheel pattern	58.5	130	468	8
L23	19/0800	Transit to GG	1.5	130	12	8
L24	0930	Rendezvous w/ HAYES & tow from GG to FF	11.5	130	20	3.5
L25	2100	Return to pinwheel	1.5	130	12	8
L26	2230	Continue pinwheel pattern	16.0	130	128	8
L27	20/1430	Transit to Y	5.5	130	45	8
L28	2200	Radial tow to O	20.0	130	162	8
L29	21/1800	Retrieve HLF	1.0	-	-	-
L30	1900	Transit to Bermuda	4.5	-	39	9
L31	2330	Arrive Bermuda				

Detailed LYNCH Eddy Tracks



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APPENDIX B - Operation Plan for USNS LYNCH

LYNCH OP PLAN - FREDDEX

Objective

The USNS LYNCH (T-AGOR-7) will serve a dual purpose as part of a major multi-platform investigation (FREDDEX) of an ocean eddy and the effect of the eddy on underwater acoustic propagation. Effects of ocean fronts are also of interest to FREDDEX.

During various segments of the operation an acoustic source will be towed to permit acoustic monitoring by other platforms. Extensive oceanographic measurements will also be carried out. The measurements will utilize expendable bathythermograph probes, a thermistor for the continuous measurement of the mixed-layer temperature, and the possible use of a CTD.

The purpose of the oceanographic measurements is to collect data on the detailed thermal structure of an oceanographic eddy and the evolution and movement of this feature over the time period of observation. This data will be used to investigate the dynamical nature of an ocean eddy and its effect on the surface mixed layer structure. The oceanographic data will serve the basic research objective of NRL project 83G0120 on spatial variability in the ocean.

Ship and Operating Areas

The USNS LYNCH (T-AGOR-7) will be the operating platform for this experiment. The operating areas will be outlined in detail upon the accurate delineation of the ocean eddy. The general operation areas are listed in Tables I, II, and III. The general schedule of events is given in a later section.

Ships Schedule

Newport, R.I.	23 May to 3 June 1979
Transit	3 June
Oceanographic Ops	4-20 June
Transit	21 June
St. George, Bermuda	21 June

Oceanographic Program

Certain descriptive remarks are made in this section about the various phases of the measurement program. A detailed schedule of events appears later in this operation plan.

A. Gulf Stream transact. LYNCH will perform XBT measurements along a line from north of the Gulf Stream to the eddy. Characterization of this track is as follows:

i) initial or starting position: 37°32'N 71°45'W
ii) bearing of track: 133° approximately
iii) length of track: 420 n. miles approximately
The oceanographic measurements along this track will reveal frontal structure and Sargasso Sea conditions between the Gulf Stream and the eddy.
iv) XBT measurements will be taken approximately every SNM.
v) During about half the track starting with the initial position an acoustic source will be towed by the LYNCH.

B. First Eddy Gear Pattern. (See figure labeled eddy gear pattern.)

i) Upon completion of A. the LYNCH will begin XBT measurements around the eddy. These measurements will occur within a 65 NM radius of the eddy center. The gear pattern is a modified star pattern which involves measurements extending from almost the eddy center to the outer extremity of the eddy. Since the eddy may shift position during the measurements some modification of the pattern must be anticipated.
ii) This portion of the measurement program will require about three days to complete.
iii) XBT sampling will occur on about a 5 NM interval.
iv) CTD work during this phase is dependent on completing the gear pattern early. It may be that no CTD work will be performed during this phase.

C. Repetitive Acoustic Tow Phase

i) Upon completion of the first gear pattern the LYNCH will begin an eight-day period of towing an acoustic source along radial lines extending from the eddy center to its extremity. Various depths will be used for the source.
ii) Several repetitive tows will be made with XBT measurements performed at about a 5 NM spacing.
iii) Fouling of XBT's with the towed source may lead to modification of the XBT sampling procedure.
iv) We do not anticipate CTD work while the acoustic source is deployed.

D. Second Gear Pattern

i) The second gear pattern will be similar to the first but with the important modification that the acoustic source will be utilized during a one-day period at the beginning of the gear pattern. It is of paramount importance that the second gear pattern be completed in order to provide two realizations of the eddy structure to satisfy the research objectives of 83G0120.
ii) Present plans call for the source to be left in the water during the entire gear pattern (even when it is off). Interference with XBT measurements will require retrieval of the source during its off-time.
iii) The total duration of the second gear pattern will be approximately three days.
iv) XBT sampling will occur on about a 5 NM interval.
v) CTD work will be performed in this phase only if time permits.

E. Final Transit Through Eddy

i) The final operation consists of towing the acoustic source from outside the eddy through the eddy center to the opposite side of the eddy.
ii) initial or starting position: 34°20'N 67°W
iii) Track distance about 80 NM
iv) Bearing about 130°
v) A limited amount of CTD work will be performed. Time will be the determining factor.

Navigation

1. Navigation will be under the direction of the Scientific Navigator. Close adherence to the desired track will be maintained on a continual basis utilizing Loran-C. Fixes will be logged and plotted every 15 minutes and whenever there is a course or speed change. Fixes will also be logged for each XBT drop and CTD cast.

2. The Micrologic 1000 Loran-C receivers and the Northstar 6000 Receiver will be used and normally will be in the Latitude/Longitude Mode. Special Loran-C charts will also be provided in the event it becomes necessary to switch to the time difference mode.

3. Satellite fixes will be logged when received and will be checked to insure that the Loran-C receivers are tracking properly.

4. Code 8004 Navigation Data logs will be provided and will be filled out in accordance with instructions provided by the Scientific Navigator.

Equipment

The following equipment is to be supplied by USNS LYNCH (NAVOCEANO):

- 2 Satellite Navigation Receivers
- 2 Micrologic 1000 Loran-C Navigation Units
- 1 3.5 kHz Bathymetry System/Recorder
- 1 12 kHz Bathymetry System/Recorder
- 1 Hydrographic winch w/conducting cable

The following equipment is to be supplied by NRL:

- All digital processing equipment - including Hewlett-Packard Mini computer systems and digital recorders.
- XBTs - both probes and recording systems.
- CTD - Neil Brown CTD system will be supplied with recording system.
- Northstar 6000 Loran-C Receiver.
- All navigation charts will be supplied.
- Radio communication equipment.

Normal working assignments will be made by the SSOB, and will be consistent with the training and qualifications of personnel; however, all personnel are subject to collateral duties if operating requirements so warrant and it is deemed necessary by the senior scientist. Operations will be conducted 24 hours a day. Overtime will be worked only as necesary, and approved by the SSOB. The watches will overlap when the watch officer is needed elsewhere. All personnel should be ready to cooperate on all launchings and retrievals of mechanical equipment if it becomes necessary. No overtime will be worked in port or on transits unless deemed necessary by the SSOB.

SAFETY PRACTICES

During the conduct of the experiment, both at sea and on land, the SSOB will be the Safety Officer of the scientific party. He will supplement the normal safety practices of the ship's Captain and crew in activities where the scientific party is involved. The following safety practices will be followed during the experiment:

1. <u>Pre-sail Inspection</u> - The SSOB will inspect all areas of the ship where the scientific party will be working to locate and eliminate all work hazards. He will solicit advice from the scientific party as to any hazard that may exist in their particular area of activity and institute action to remove or minimize them.

2. <u>Loading and Off-loading Coordinator</u> - During the loading and off-loading of scientific equipment in port, Code 8004 will designate a coordinator to supervise these operations and to act for the SSOB in all matters concerning safety practices.

3. <u>Launching and Retrieval of Equipment at Sea</u> - Prior to the launching and retrieval of equipment at sea, the SSOB will hold a meeting with a pre-selected launch/retrieval coordinator and members of the scientific team. At the meeting, a review of all launching/retrieval procedures will be made and specific duties will be assigned to each team member. During actual launching/retrieval operations, all members of the scientific party <u>not</u> assigned to the team are to stay clear of the work area. The SSOB or launch/retrieval coordinator will be on deck during all launching and retrieval operations to insure all safety procedures are followed.

TABLE I. FREDDEX Coordinates

POSITION	LAT	LONG
A	33 00	61 00
B	33 40	62 45
C	33 40	69 45
D	32 50	66 15
E	36 00	66 15
F	34 00	63 05
G	33 20	62 25
H	35 33	69 15
I	34 30	70 00
J	33 30	70 00
K	32 30	70 00
L	32 30	68 00
M	33 30	68 00
N	34 30	68 00
O	32 30	64 00
P	34 30	66 00
Q	32 30	66 00
R	34 00	69 00
S	37 32	71 45
T	34 15	69 00
U	33 40	64 00
V	34 30	62 45
W	37 20	73 30
X	35 00	61 00
Y	34 30	61 50
Z	39 00	68 00
AA	32 00	61 00
BB	33 20	62 45
CC	33 40	65 30
DD	33 40	66 15
EE	35 05	66 15
FF	34 00	64 00
GG	33 20	64 00
HH	34 20	64 00
KK	33 40	61 30
SS	39 45	70 45
WW	37 20	74 30
Newport	41 30	71 30
Narranganset	41 30	71 30
Bermuda	32 20	64 45
Cape Henry	37 00	76 00

TABLE II. DETAILED USNS HAYES SCHEDULE FOR FREDDEX

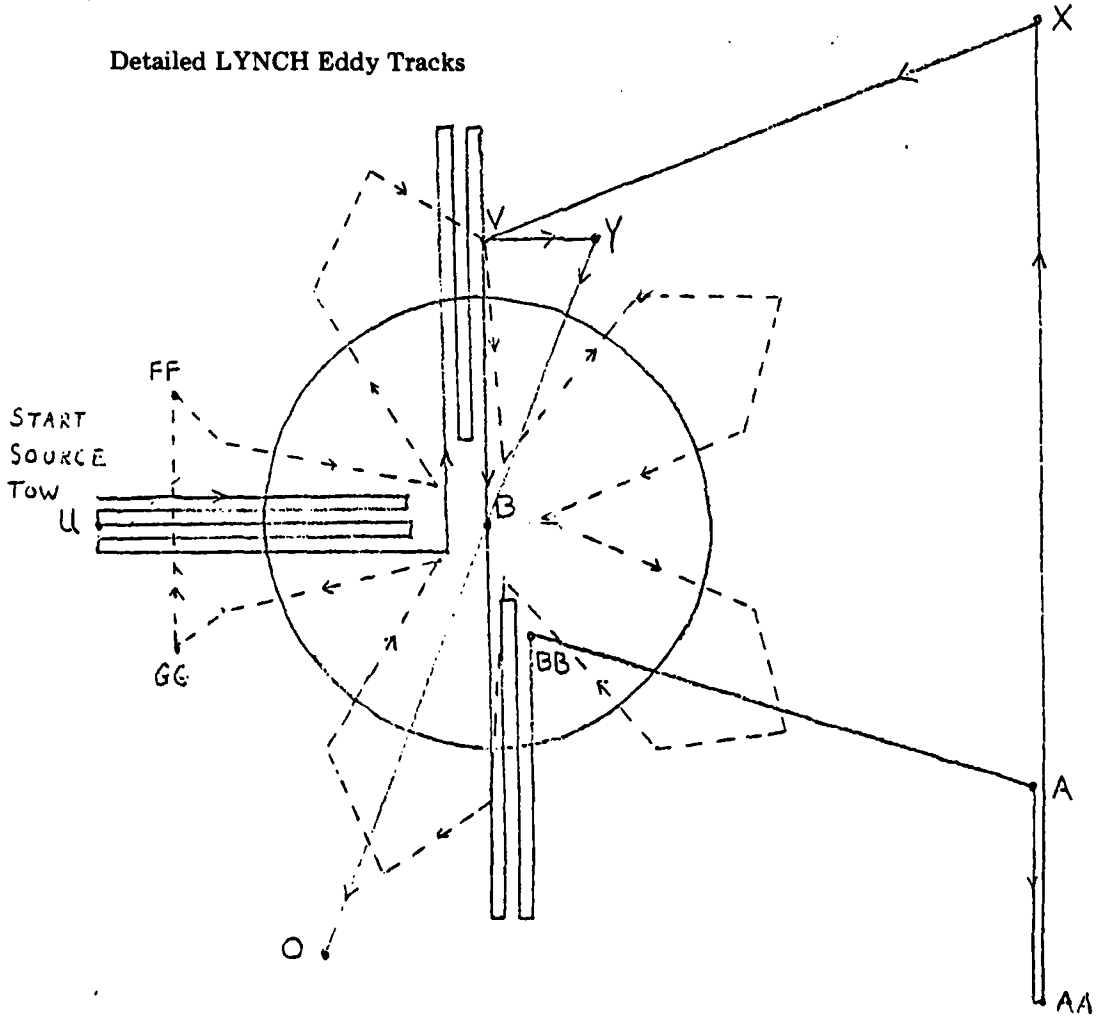
EVENT	START TIME(Z)	DESCRIPTION	DURATION (HR)	DISTANCE (MI)	SPEED (KT)
H01	04/1200	Transit to Yorktown	1.0		
H02	1300	Load explosives	2.0		
H03	1500	Transit to Crainy Is.	4.0		
H04	1900	Load fuel	5.0		
H05	05/0001	Transit to Cape Henry	3.0		
H06	0300	Transit to WW	7.5	74	10
H07	1030	Transit to W & launch balloons	4.0	48	12
H08	1430	Transit to C	22.0	286	13
H09	06/1230	Deploy 230 Hz source	5.0		
H10	1730	Transit to KK	30.5	412	13.5
H11	08/0001	Transit to A	3.5	47	13.5
H12	0330	Deploy 224, 350 Hz sources	5.0		
H13	0830	Transit to B	7.5	96	13
H14	1600	Deploy 227, 162 Hz sources	5.0		
H15	2100	Transit to DD	13.5	175	13
H16	09/1030	Deploy MFA at DD	10.5		
H17	2100	Tow MFA on 000°T	40.0	140	3.5
H18	11/1300	Turn at E	2.0		
H19	1500	Tow MFA on 180°T	52.5	190	3.5
H20	13/1930	Turn at D	2.0		
H21	2130	Tow MFA on 000°T	38.5	135	3.5
H22	15/1200	Turn at EE	2.0		
H23	1400	Tow MFA on 180°T	38.5	135	3.5
H24	17/0430	Turn at D	2.0		
H25	0630	Tow MFA on 000°T	14.5	50	3.5
H26	2100	Turn at DD	1.0		
H27	2200	Tow MFA on 090°T	10.5	37	3.5
H28	18/0830	Retrieve MFA at CC	4.5		
H29	1300	Transit to HH	7.0	85	12
H30	2000	Deploy MFA	8.0		
H31	19/0400	Tow MFA on 000°T	5.5	20	3.5
H32	0930	Rendezvous w/ LYNCH at GG	0.0		
H33	0930	Tow MFA to FF	11.5	20	3.5
H34	2100	Change course at FF	1.0		
H35	2200	Tow MFA on 090° to F	13.0	46	3.5
H36	20/1100	Change course at F	1.0		
H37	1200	Tow MFA toward G	15.0	52	3.5
H38	21/0200	Turn 180° at G	2.0		
H39	0400	Tow MFA toward B	7.5	26	3.5
H40	1130	Retrieve MFA & 2 sources at B	14.5		
H41	22/0200	Transit to A	8.0	96	12
H42	1000	Retrieve 2 sources at A	10.0		
H43	2000	Transit to C	36.5	440	12
H44	24/0830	Retrieve source at C	5.0		
H45	1330	Transit to Cape Henry	28.0	365	13
H46	25/1730	Transit to Cheatham	6.0		
H47	2330	Arrive Cheatham			

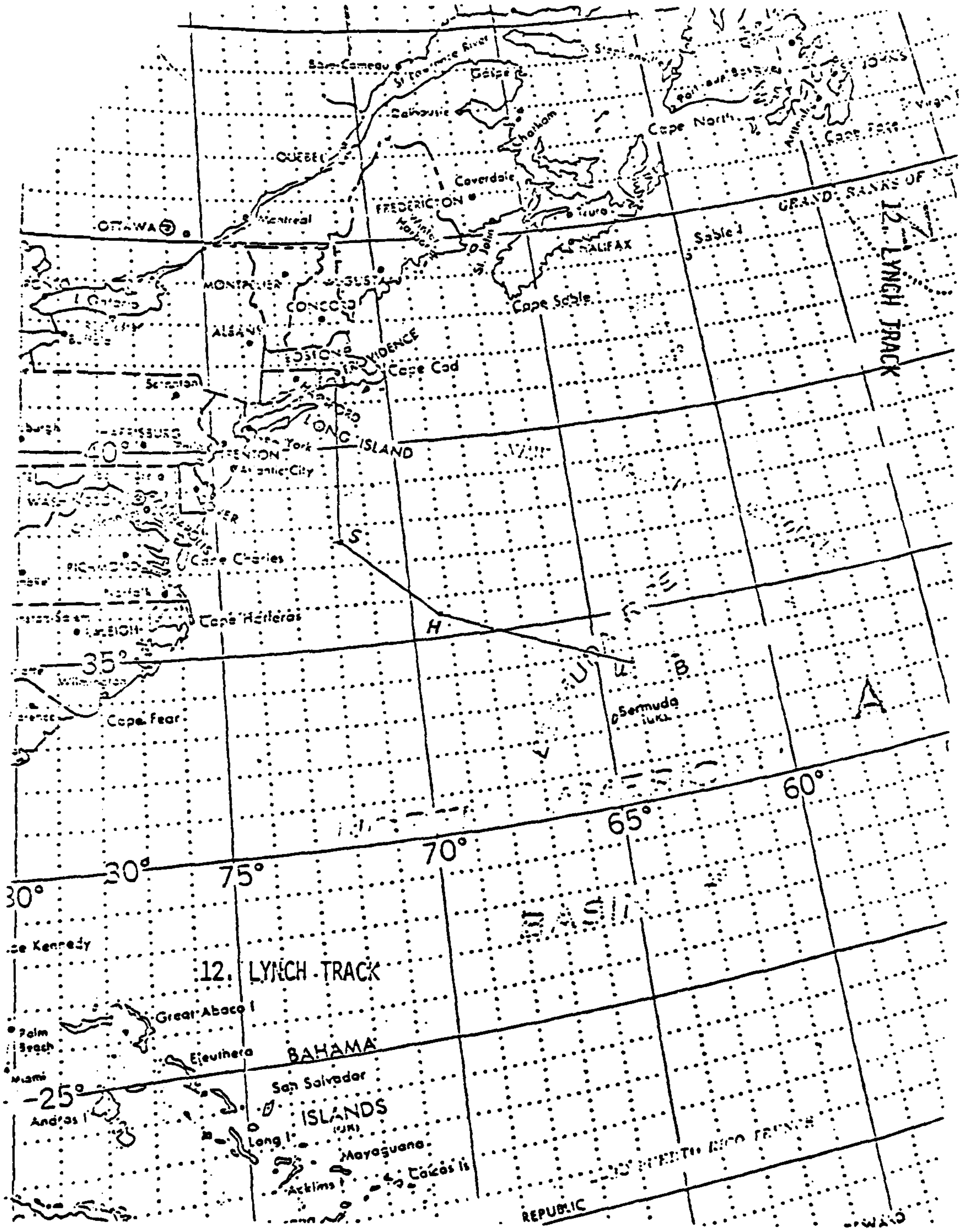
25 May 1979

TABLE III. DETAILED LYNCH SCHEDULE FOR FREDDEX

EVENT	START TIME (Z)	DESCRIPTION	DURATION (HR)	SOURCE DEPTH (M)	DISTANCE (MI)	SPEED (KT)
L01	03/1030	Transit to S	26.4	-	238	9
L02	04/1300	Deploy HLF at S	1.0	-	-	-
L03	1400	Tow HLF to H	2.31	30	169	8
L04	05/1130	Change course; tow to U	31.4	30	283	9
L05	06/1900	Pinwheel eddy sampling	74.0	30-150	640	8.6
L06	09/2100	Acoustic pattern in eddy	8.0	130	56	7
L07	10/0500		8.0	130	56	7
L08	1300		8.0	50	56	7
L09	2100		8.0	50	56	7
L10	11/0500	Tow U to B	10.0	130	62	6.2
L11	1500		10.0	130	70	7
L12	12/0100		8.0	50	56	7
L13	0900		8.0	50	56	7
L14	1700		20.0	130	140	7
L15	13/1300		8.0	50	56	7
L16	2100		8.0	50	56	7
L17	14/0500		10.0	130	70	7
L18	1500	Tow BB to A	13.0	130	90	7
L19	15/0400	Tow A to AA	8.5	130	60	7
L20	1230	Tow AA to X	21.5	130	150	7
L21	16/1000	Transit to V	11.5	130	91	7
L22	2130	Start pinwheel pattern	58.5	130	468	8
L23	19/0800	Transit to GG	1.5	130	12	8
L24	0930	Rendezvous w/ HAYES & tow from GG to FF	11.5	130	20	3.5
L25	2100	Return to pinwheel	1.5	130	12	8
L26	2230	Continue pinwheel pattern	16.0	130	128	8
L27	20/1430	Transit to Y	5.5	130	45	8
L28	2200	Radial tow to O	20.0	130	162	8
L29	21/1800	Retrieve HLF	1.0	-	-	-
L30	1900	Transit to Bermuda	4.5	-	39	9
L31	2330	Arrive Bermuda				

Detailed LYNCH Eddy Tracks




12. LYNCH TRACK
Cape Cod
LONG ISLAND
Cape Charles
Cape Hatteras
Cape Fear
Bermuda
BAHAMA
ISLANDS
San Salvador
Great Abaco I
Eleuthera
Cape Sable
HALIFAX
Cape North
QUEBEC
Montreal
FREDERICTON
Coverdale
Dalhousie
40°
35°
30°
25°
75°
70°
65°
60°
BASIN
Mayaguana
Caicos Is
Long I
Acklins I
REPUBLIC
Cape Kennedy
Wilmington
Atlantic City
Sable I
GRAND BANKS OF
S
H
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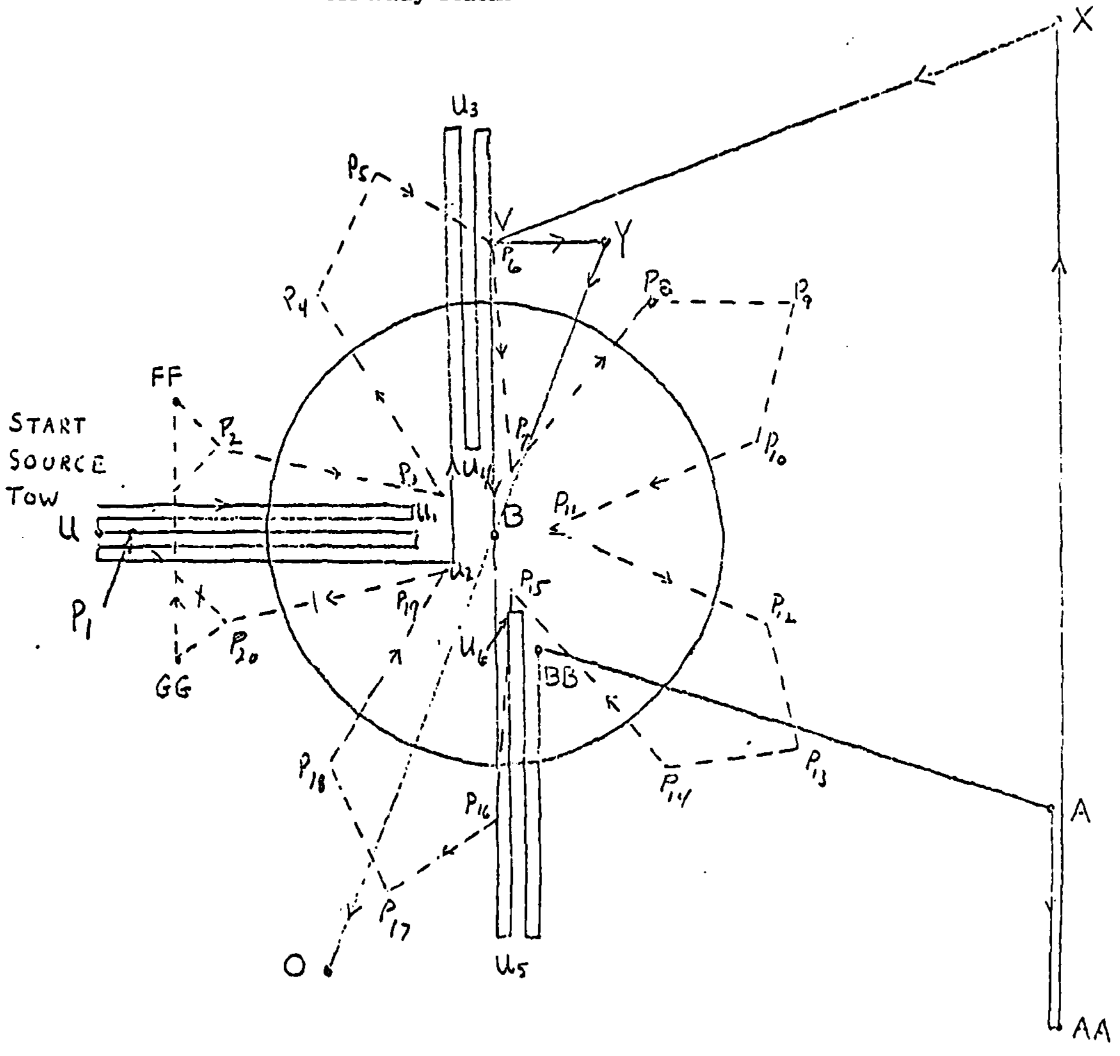
13. EDDY EXPERIMENT TRACK DETAILS

Detailed LYNCH Eddy Tracks



May 25, 1979

APPENDIX C - Operation Plan for R/V ENDEAVOR

TECHNICAL SPECIFICATION FOR OCEANOGRAPHIC
SURVEY OPERATIONS 370901 ABOARD R/V
ENDEAVOR, 4-30 JUNE 1979

I. INTRODUCTION

1.1 Background - During May 1978, NAVOCEANO successfully completed Frontal Oceanographic Exercise-I (FOX-I), a multi-platform acoustic exercise designed to determine the affects of the Gulf Stream and an anticyclonic eddy during ASW operations. This year's operation, FOX-II, will investigate the acoustic affects of a cyclonic eddy and will be conducted in coordination with FREDDEX, an NRL sponsored acoustic modeling experiment.

1.2 Scope - This survey will be a combined operation using the R/V ENDEAVOR, USNS LYNCH (T-AGOR-7), USNS HAYES (T-AGOR-16), the BIRDSEYE aircraft, and several Fleet assets. These specifications will define the scope of this investigation and provide guidance for data collection from ENDEAVOR during June 1979. The Senior NAVOCEANO Representative may modify the operational phases of this survey, within limits, to best define oceanographic parameters, to assure data quality and to best use time available.

1.3 Purpose - The purpose of this survey will be to obtain extensive oceanographic measurements to provide a complete record of environmental conditions present during FREDDEX/FOX-II operations.

2.0 TECHNICAL PROGRAM

2.1 Introduction - This survey will be conducted by the Tactical Analysis Division, Fleet Applications Department, Naval Oceanographic Office. The procedural sequence and time duration of various phases will be the responsibility of the SNR.

2.2 Approach - ENDEAVOR will depart Narragansett, RI on 4 June and proceed to the OPAREA (Figure 1). Shipboard expendable bathythermographs (SXBTs) will be dropped along the track line from point S to point E every 10 km. When cold (9°C) Shelf water is encountered along the edge of the Gulf Stream, the spacing will be reduced to 3 km. A shallow (300 m) SVSTD station will be taken in the entrained Shelf water. After this, ENDEAVOR, already in communication with BIRDSEYE, will implant four sonobuoys as markers in oceanographic features. BIRDSEYE will then deploy additional sonobuoys in these features to perform ambient noise measurements. So as not to interfere with BIRDSEYE measurements, ENDEAVOR will then continue along its track to point E where an SVSTD station will be taken.

ENDEAVOR will proceed to other points as indicated on Figure 1 and take SVSTD stations. After leaving point Q, a pinwheel pattern will be followed to define the cyclonic ring's structure. Upon completion of the pinwheel, a line of SVSTD's will be taken through the ring center to the Gulf Stream. SVSTDs will be taken to the bottom every 10 km in the ring. Upon completion of the last SVSTD station in that line the ENDEAVOR will then go through the Gulf Stream and head towards Bermuda for a one day inport.

The ENDEAVOR will depart Bermuda and occupy SVSTD stations along a line through the ring center. After finishing the last SVSTD station along that radial, ENDEAVOR will then proceed to map the Gulf Stream and investigate the depth and extent of 18°C water with SXBTs. The ENDEAVOR will return to Narragansett, RI on 30 June.

3.0 LOGISTICS

3.1 Security - All data collected aboard ENDEAVOR will be of an UNCLASSIFIED nature

3.2 Personnel - Personnel required to complete this survey are:

1 Senior NAVOCEANO Representative	Code 3710
4 Oceanographers	Code 3710, Old Dominion University, University of Rhode Island
1 Physical Science Aid	Code 3720
3 Electronics Technicians	Code 6110, University of Rhode Islan
5 Midshipmen	U.S. Naval Academy

3.3 Instrumentation - The following NAVOCEANO instrumentation will be required in addition to that found aboard ENDEAVOR:

1 Calibrated SVSTD system
1 digital data logger
1 SVSTD digital display
1 digital printer
1 SVSTD analog recorder
1 rechargeable acoustic pinger
1 Rosette sampler with deck firing unit
780 Shipboard Expendable Bathythermograph Probes (T-7)
300 Shipboard Expendable Bathythermograph Probes (T-4)
6 AN/SSQ-57A Sonobuoys
2 AN/SSQ-41B Sonobuoys

3.4 Communications - SSB communications will be established between ENDEAVOR, BIRDSEYE, LYNCH, and Tudor Hill Laboratories, Bermuda.

Frequencies to be used are:

7690.0 KHz (Primary)
4482.5 KHz (Secondary)
2200.0 KHz (Tertiary)

There will be no classified transmissions.

3.5 Operating Area Clearance Requests - All OPAREA clearance will be coordinated through USNS LYNCH.

4.0 SAMPLING METHODS

4.1 SXBT Observations - Shipboard expendable bathythermographs will be annotated with: NAME OF VESSEL, CRUISE NUMBER, POSITION, DATE, TIME (GMT), and CONSECUTIVE NUMBER regardless of whether the SXBT probe was good or not. If any SXBT trace is determined by the observer to be questionable, another probe should be launched immediately to confirm or deny the trace described. This second trace should be assigned a new consecutive number. SXBT sampling interval will be determined by the SNR. Selected SXBTs will be transmitted to LYNCH or BIRDSEYE for retransmission to FLENUMWEACEN, Monterey, CA.

4.2 SVSTD Observations - All SVSTD observations will be made in accordance with NAVOCEANO manual Standard Procedures for Collecting and Processing SVSTD Data (April 1975).

4.3 Navigation - Navigation will be primarily by satellite, LORAN C and LORAN A. A scientific navigation log will be maintained in the chart room listing: TIME (GMT), DATE, TYPE and RELIABILITY OF FIX, SATELLITE ELEVATION, RATE LINE (when applicable), GEOGRAPHIC POSTION, COURSE STEERED, SPEED MADE GOOD, COURSE MADE GOOD. Fixes should be taken every 15 minutes, plotted every 30 minutes, and taken at all SXBT drops, at the beginning and end of all SVSTD stations, and at all course and speed changes.

4.4 Weather Observations - A weather log will be maintained in the chart room, by the Officer on Watch, listing: DATE, TIME (GMT), WIND DIRECTION and VELOCITY, DIRECTION and HEIGHT OF SEAS, DIRECTION and HEIGHT OF SWELL, CLOUD TYPE and AMOUNT, WET and DRY BULB TEMPERATURE, BAROMETRIC PRESSURE, WEATHER and VISIBILITY. Observations will be made at intervals not to exceed two hours.

4.5 Bathymetry - Bathymetric data will be recorded continuously during the survey except during SVSTD stations. PDR traces will be annotated hourly with TIME (GMT), DATE, DEPTH, SCALE, COURSE, SPEED, and STATION NUMBER (where applicable). All marks on the PDR trace will be made with felt-tip pen.

5.0 DATA REDUCTION AND REPORTS

Preliminary data reduction will be accomplished aboard ship before debarkation at the termination of the survey. NAVOCEANO Technical Notes will be prepared by the Tactical Analysis Division.

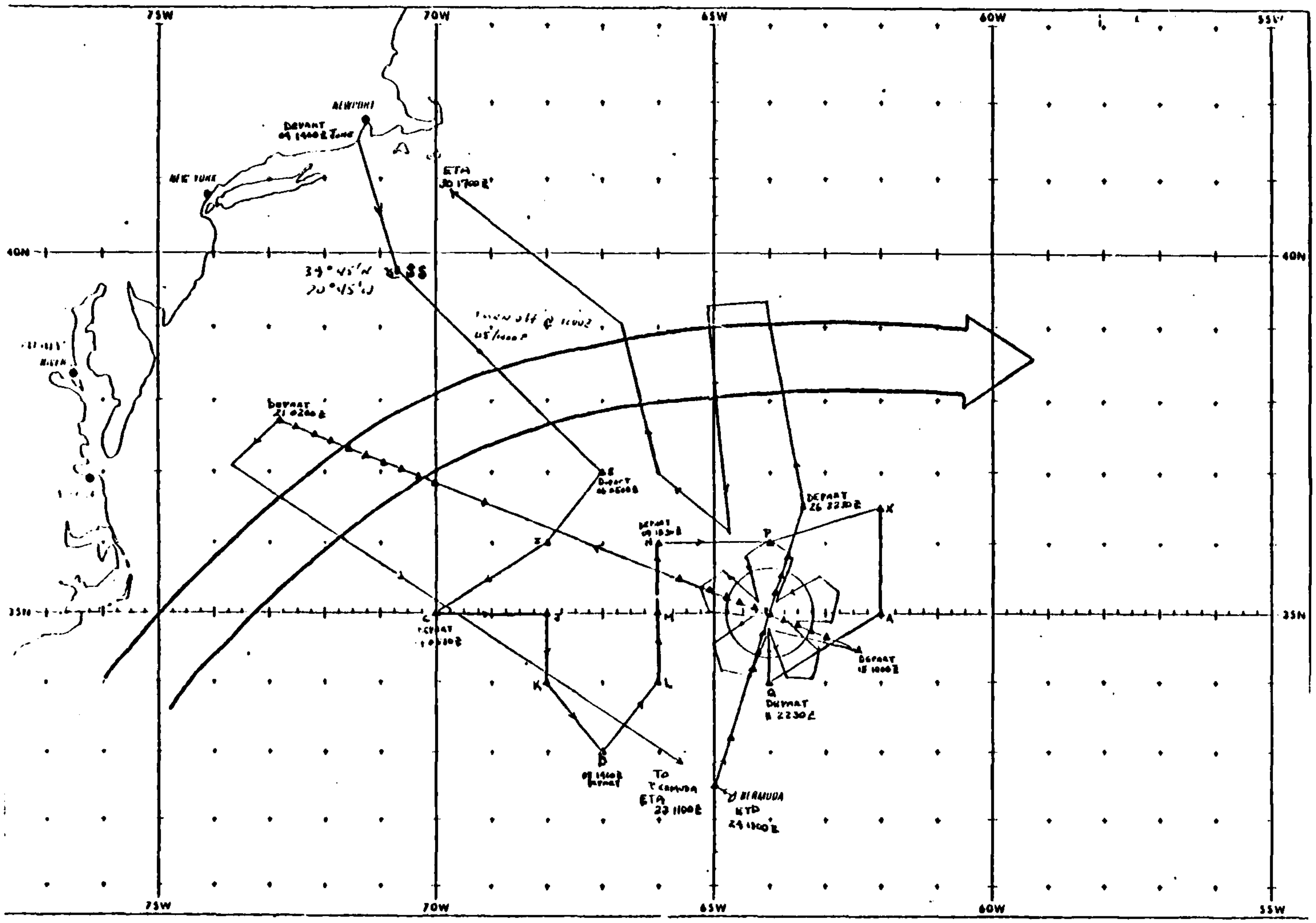


Fig. C1 - Anticipated Cruise Track for R/V ENDEAVOR.

May 25, 1979

APPENDIX D - Operation Plan for NRL Aircraft SUS Flights

FREDDEX Flights 6 and 8 (SUS Operations)

1. Objective - Measure towed array shape.

2. Assets - NRL aircraft (SUS) and USNS HAYES (towed array).

3. Op Area - Along 66 15 W between 33 00 and 36 00 N.

4. Personnel - The project engineer, Skip Kovacs (Code 8110, x2024) will be the only scientific member participating in these two flights. A photographer from ONR (Mr. Mike Gummerson or his representative) will be on one of these flights to capture the experiment on movie film.

5. Schedule - Flights on 11 and 15 June, 1979 with COMEX over USNS HAYES at approximately 1400Z.

6. Flight Plan Mark over USNS HAYES (see figure 1) and fly a course 045°R to HAYES track for 5 miles and drop a Mk 58 smoke marker at A. Circle and mark over A and fly a course of 270°R to HAYES for 7 miles and drop another Mk 58 smoke marker at B. HAYES should be directly between the smokes 1 hour after they are dropped.

Next, fly the pattern BCAD and drop a Mk 64 SUS set for 800' precisely over the smokes at A and B on each pass. The pattern is 16 miles in perimeter and takes 4 minutes to complete at 240 kts. It is important to keep the timing accurate, but more important to drop the SUS directly over the smokes.

The first sequence is complete when the pattern has been executed 30 times (120 minutes). On the 11th and 21st passes deploy new Mk 58 smokes along with the SUS since the lifetime of the buoys is approximately 10 patterns or 40 minutes.

After the 30th pattern, begin the second sequence by repositioning the aircraft over HAYES and repeating the procedure for laying buoys given above. Again, fly the 4-minute BCAD patterns dropping Mk 64 SUS every 2 minutes and smokes every 40 minutes. As before, lay new smokes along with the SUS on the 11th and 21st passes. The second sequence also requires 30 patterns or 120 minutes to complete.

The third sequence begins as above with new buoys, but requires 40 patterns (160 minutes) to complete. During this sequence Mk 83 SUS set for 1500' (possibly labeled Ex Mk 64 Mod 1) will be dropped. New smokes will be deployed (along with SUS) on the 11th, 21st and 31st patterns.

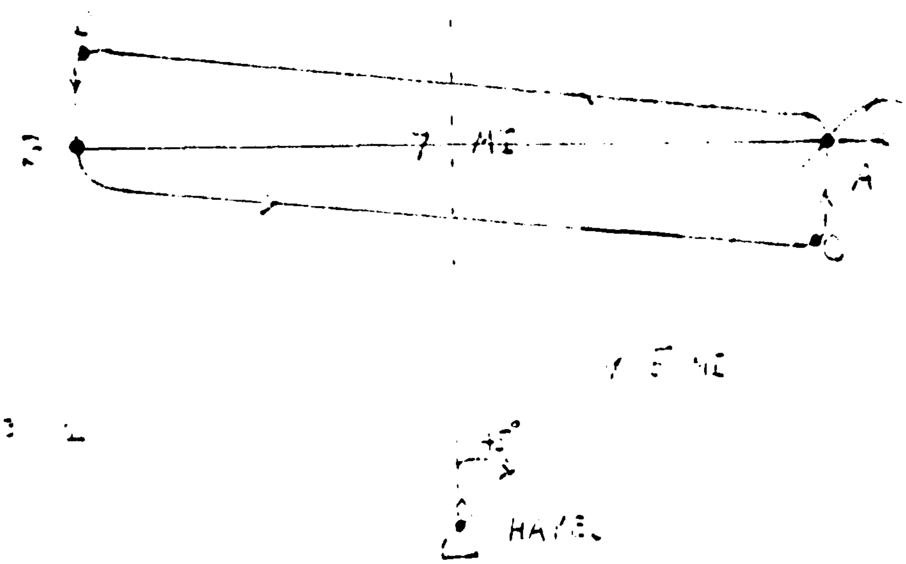
7. Expendables - 120 Mk 64s set for 800 feet and 80 Mk 83 SUS set for 1500 feet and 26 Mk 58 smokes (includes 6 spares) for each flight.

Sequence	Type	Drop Interval (minutes)	Duration (minutes)	#
1	Mk 64 (800')	2.0	120	60 Mk 64s
	Mk 58 (pair)	10.0	-	6 Mk 58s
2	Mk 64 (800')	2.0	120	60 Mk 64s
	Mk 58 (pair)	10.0	-	6 Mk 58s
3	Mk 83 (1500')	2.0	160	80 Mk 83s
	Mk 58 (pair)	10.0	-	8 Mk 58s

8. In-flight Req. - Op services is requested to locate an ordnance man to handle the SUS. A drop log will be kept by the project engineer indicating DAY, TIME (GMT), DROP #, SEQUENCE, PATTERN #, TYPE OF SUS, PORT or STARBOARD SIDE of HAYES, etc. For each drop, an estimate of the splash location relative to the smoke will also be logged.

9. Communications - All traffic prior to the flight days will be relayed between HAYES and NRL Flight Detachment (PAX RIVER) via NRL Code 8004 radio checks to the Project Engineer. In particular, HAYES estimated position at 1400Z on 11 and 15 June will be transmitted on the previous days radio check. During the transit to HAYES, HF SSB 7690.0 KHz (4482.5 KHz secondary) will be used to coordinate rendezvous. During the operation in the vicinity of HAYES, a 328.8 MHz UHF radio link will be used as primary (7690.0 KHz HF SSB secondary). The call signs are Researcher 55 for HAYES and Researcher 674 for the aircraft.

10. Flight delays - If delays occur, then these two flights can be rescheduled between 11 and 17 June, 1979.



May 25, 1979

APPENDIX E - Mesoscale Environmental Effects on ASW Working Group

DEPARTMENT OF THE NAVY
HEADQUARTERS NAVAL MATERIAL COMMAND
WASHINGTON, D. C. 20360

IN REPLY REFER TO
08T24/GRS
3 OCT 1978

From: Naval Material Command
To: Distribution

Subj: Mesoscale Environmental Effects on ASW Working Group

1. The Chief of Naval Material, NAVMAT 08T245, has established a working group to coordinate a tactical and surveillance related investigation of mesoscale ocean environmental features. The purpose of the group is to provide a mechanism for joint planning, data exchange, potential exercise conduct, and other common interests. In addition to the coordination of NAVMAT supported work, the group will seek collaboration for specific studies with common interest groups such as the Naval Oceanographic Office and Office of Naval Research.

2. The first formal meeting of this group occurred on 7 September 78, for the refinement of objectives and planning of a 3rd Quarter FY 79 exercise in the Atlantic north of Bermuda. Representatives from Naval Underwater Systems Center (NUSC), Naval Research Laboratory, (NRL), Naval Ocean Research and Development Activity (NORDA), Chief of Naval Operations (OP-095), Office of the Oceanographer of the Navy (OCEANAV), Office of Naval Research (ONR), Chief of Naval Material (NAVMAT), were present and agreed in substance to coordinate the following studies, listed with conducting and supporting organizations and task leader.

a. Tactical ASW study relative to mobile ship sonar and weapons; NUSC (NAVMAT)-W. Shumacher

b. Surveillance ASW study relative to high resolution towed arrays. NRL (NAVMAT)-W. Moseley

c. Environmental support for tactical ASW study, (NORDA) (NAVMAT) D. Fenner

Major collaborating programs are:

a. Environmental effects on tactical and surveillance sonars. NAVOCEAN (OCEANAV) M. Shank

b. Fixed system environmental effects IAR, (ONR) J. Clark

Associated ONR programs are:

a. Mesoscale monitoring with low frequency OTH Radar, NRL (ONR), D. Trisna

b. Ocean dynamics and stocastic propagation NRL, (ONR) J. Dugan

c. IR and altimetry on mesoscale features NRL, (ONR) V. Novle

d. Possible participation by Woods Hole (R. Spindel) will be investigated.

3. The next meeting will be at the Naval Research Laboratory on 11 October 78, Rm. 207, Bldg. 1 at 9:00. The purpose is to continue exercise definition and planning and to obtain statements of specific responsibility with the cognizant individual, where different from the task leaders. As stated in paragraph 1, the objective of the working group, is to increase the effectiveness of all the participants , through coordination and data exchange. The pricipals and major collaborators will conduct the exercise, providing and soliciting support from the associated programs. Dr. W. Mosely, was chosen senior scientist by members present on 7 September 78, and will serve as contact point for general information.

Dist:
NUSC-(Code 10, 312)
NRL-(Code 8160, 8341, 7006, 8100, 5323T, 8000)
NAVOCEANO-(Code 3700)
ONR-(Code 102, 222, 480)
NORDA-(Code 341, 200)
OPNAV-(Code 95E, 952)
ASRES (REAT)
NAVELEX-(Code 0320, PME-124
NAVSEA- (06H1)
PM-4
IAR (J. Clark)
Woods Hole Oceanographic Institution

May 25, 1979

APPENDIX F - Reverberation Measurements Using Explosive Sources

8160-137:REF:ial
29 May 1979

PROJECT FREDDEX

REVERBERATION MEASUREMENTS USING EXPLOSIVE SOURCES

During conduct of the FREDDEX experiment, explosive sources of various designs will be deployed from USNS HAYES to measure several important aspects of low frequency reverberation. Data will be received on the mid-frequency array and recorded on analog tape for post-experimental processing at NRL. The objectives are to obtain measurements on:

I. Directional surface scattering strength.
II. Reverberation suppression with vertically directive sources.
III. Basin reverberation ringing times.

Design characteristics of the explosive sources for each objective are described below. Quantities, repetition rates, and sea time required (dedicated or transparent) are also given.

I. <u>Surface Scattering Strength</u>

Charge Design: One M1 block taped to one 1.8-lb MK 94-0 SUS.
A drag chute is attached to each SUS to have the charge sink slowly so that it detonates directly under the array.
The desired geometry is shown in Fig. 1.

Detonation Depth: 2000 ft.

Bubble Frequency: 77 Hz

Quantity: 200 charges, divided into 10 sets of 20 charges each.

Repetition Rate: 1 minute between charges in a given set.

Schedule/Time Required: Each set requires 30 min dedicated sea time. The 10 sets will be deployed on an opportinity basis throughout the test schedule to sample a variety of sea conditions.

Comments: Drag chutes are trimmed to adjust sink rate. Desired sink rate depends on tow speed and horizontal distance of array center behind tow ship. The sink rate should be calculated for actual test conditions. Nominal sink rate is 2.92 ft/sec for an estimated tow speed of 3.5 knots and a horizontal distance of array center behind tow ship of 4050 ft (corresponds to array depth of 820 ft).

II. Reverberation Suppression with Vertically Directive Sources

Charge Designs:

A. 50-lb Omnidirectional Charge: six 8-lb TNT blocks plus one 1.8-lb MK 94-0 SUS.

B. 3-Element Straight-Burning Array: array is constructed to fire in sequence from bottom to top three equally-spaced elements connected by Primacord. The upper two elements each consist of two M1 blocks. The lowermost element is one MK 94-0 SUS plus one M1 block plus 1.25 lb C4. The element spacing is 24 meters. See Fig. 2.

C. 3-Element Horizontally-Steered Array: array is constructed to simultaneously detonate three equally-spaced elements connected by Primacord to a firing mechanism. The three elements are each two M1 blocks. The element spacing is 16 meters. See Fig. 3.

Detonation Depth: 5000 ft.

Bubble Frequency: for 50 lb. omni: 76 Hz
for arrays: 150 Hz

Quantity: 5 of each of the three types of charges

Repetition Rate: 15 minute intervals

Schedule/Time Required: The charges are dropped in the sequence A, B, C (one 50-lb omni, one 3-element straight-burning array, one 3-element horizontally-steered array). The sequence will be gone through three times at one location, requiring 2 hrs. 15 min of dedicated sea time. The sequence will be performed two times at another location, requiring 1 hr., 30 min of dedicated sea time. At the discretion of the SSOB, the operation could be done in one blcok of time, going through the sequence 5 times at one location.

Comments: A scheduled block of time for these charges may be delayed or terminated early if the SSOB and explosives expert determine that charge design C is not working properly.

II'. Horizontally-Steered Arrays of Five to Nine Elements

The purpose here is to extend the construction design of the 3-element horizontally-steered array to test simultaneous detonation of up to nine elements in an array.

Charge Design: arrays are constructed to simultaneously detonate five, seven, or nine equally-spaced elements connected by Primacord to a firing mechanism. The elements are each two M1 blocks. The element spacing varies:

5-element array, spacing = 9.6m
7-element array, spacing = 6.9m
9-element array, spacing = 5.3m

Detonation Depth: 5000 ft

Bubble Frequency: 150 Hz

Quantity: 5 arrays; enough material available to make each a 9-element array.

Repetition Rate: nominally, one hour.

Schedule/Time Required: no fixed schedule or location is required. Evaluation of the construction technique is the critical point here. A maximum of 5 one-hour recording intervals is required, and time should be transparent to other events.

Comments: Given success of these arrays, it would be advantageous to detonate them in periods adjacent to those being scheduled for the sequences described in II. This is not a high priority requirement, however.

III. Basin Reverberation Ringing Time

Charge Design: 11-element straight-burning array.
Array is constructed to fire in sequence from bottom to top eleven equally-spaced elements connected by Primacord. The 10 upper elements are each two M1 blocks. The bottom element is one MK 94-0 SUS plus one M1 block plus 1.25-lb C4. The element spacing is 5 meters (16.4 ft). See Fig. 4.

Detonation Depth: 5000 ft

Bubble Frequency: 150 Hz

Quantity: 10 arrays

Repetition Rate: no less than one hour.

Schedule/Time Required: It is planned to space these 10 arrays throughout the exercise as determined by the SSOB. After an array is detonated, a one-hour recording time is needed. This time should be transparent to other events.

Comments: This is a proven array design. As such, there should be no contingencies associated with the scheduling.

Figure 1 : Surface Scattering Measurements

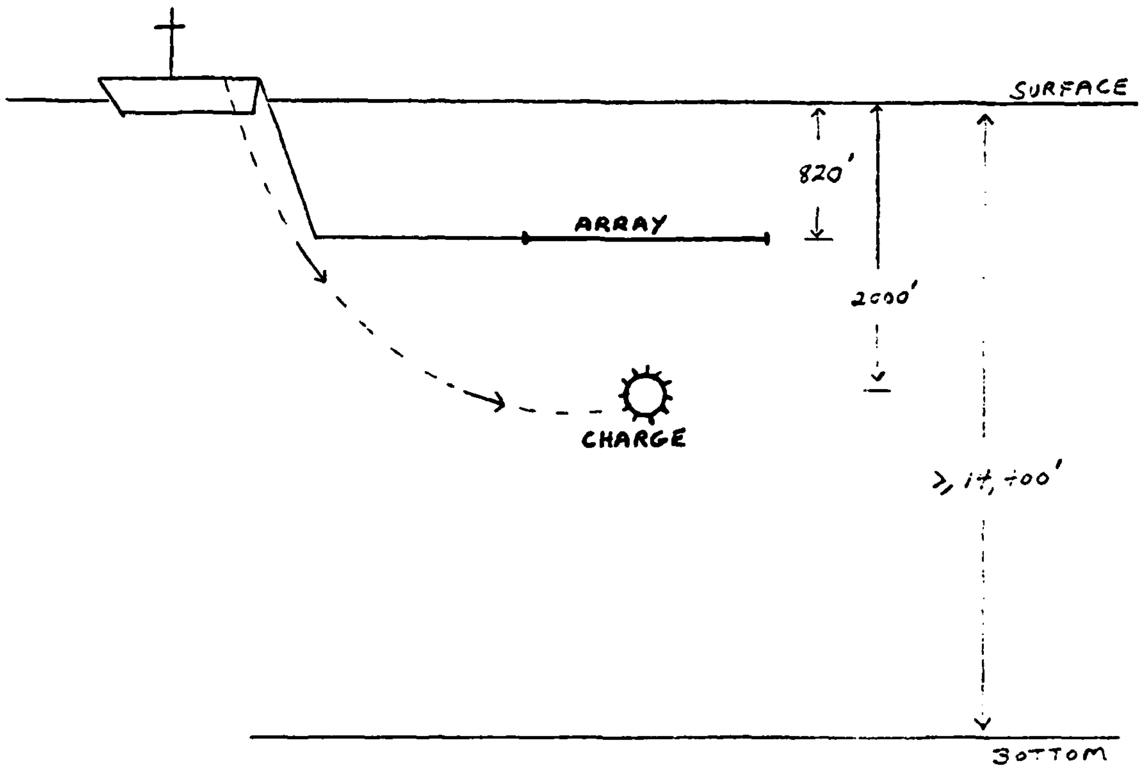
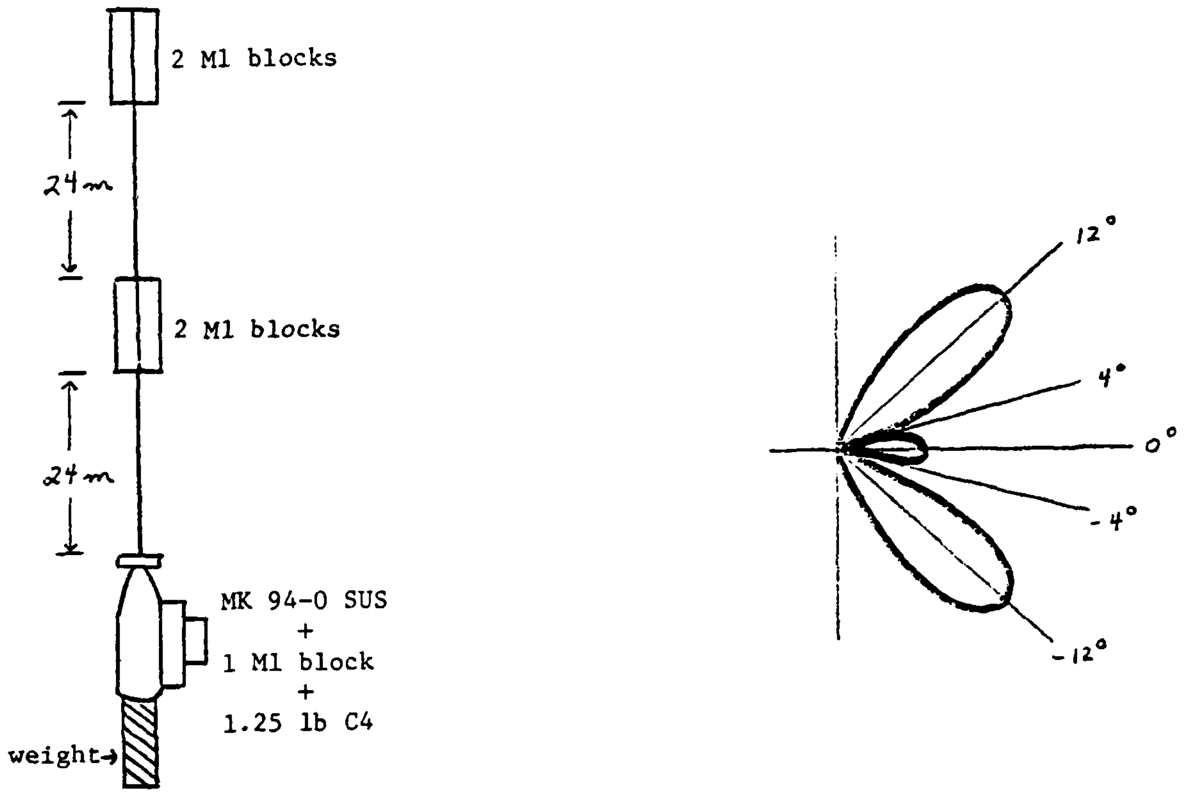
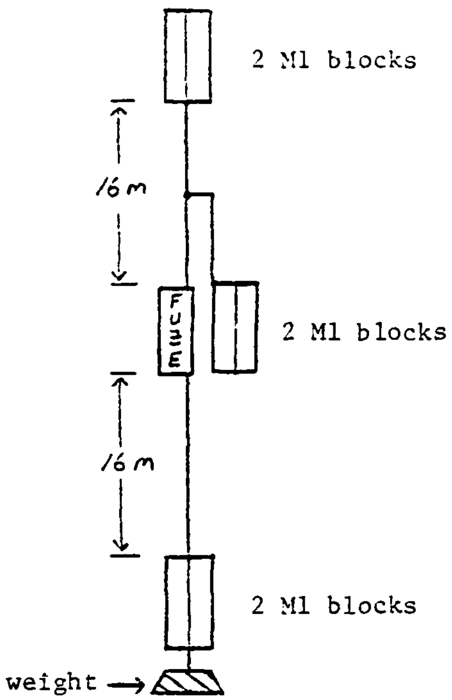


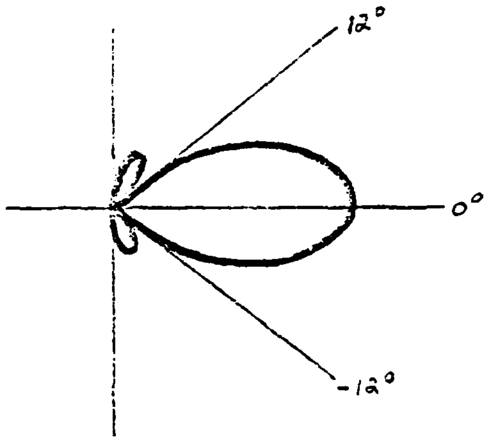
Figure 2: Three-Element Straight-Burning Array



Number Elements:	3
Charge Element Size:	6.1 lb TNT equivalent
Element Spacing:	24 m
Detonation Depth:	5000 ft
Bubble Frequency:	150 Hz
Main Beam Steer:	+12°
First Alias:	-12°
Nulls:	± 4°

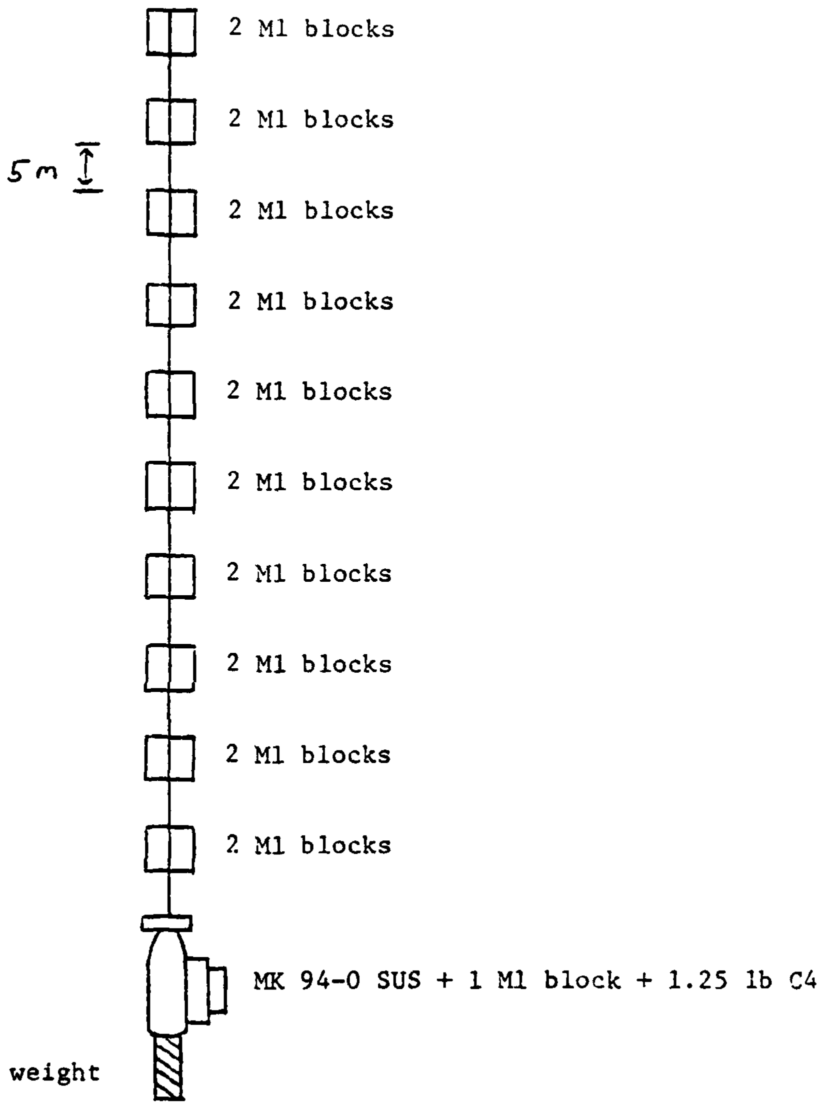
Figure 3: Three-Element Horizontally-Steered Array





Number Elements:	3
Charge Element Size:	6.1 lb TNT equivalent
Element Spacing:	16 m
Detonation Depth:	5000 ft
Bubble Frequency:	150 Hz
Main Beam Steer:	0°
First Nulls:	± 12°

Figure 4: Eleven-Element Straight-Burning Array



Number Elements:	11
Charge Element Size:	6.1 lb TNT equivalent
Element Spacing:	5 m
Detonation Depth:	5000 ft
Bubble Frequency:	150 Hz
Main Beam Steer:	+12°

APPENDIX G - Operation Plan for NRL Airborne Environmental Surveys

A. Project Title

FREDDEX - Aircraft operations

B. Project Engineers

To be determined

C. Statement of Project Objectives

The main objective of the aircraft operations is to gather data on an ocean eddy and its surrounding environment. An ocean eddy is an oceanographic feature which manifests itself as a temperature anomaly; it is roughly circular in form with a diameter of about 100 nm. Environmental data will consist of temperature measurements obtained by deployment of AXBT probes. These data will be used in the planning and execution of a major ship exercise to occur in June.

Flights devoted to AXBT measurements may involve either a search for an eddy or a survey of an already located eddy. The difference between these two categories is outlined in E.

D. Number/Length of Flights

24 April*	Tuesday	AXBT eddy search or survey	~ 10 hrs
25 April*	Thursday	AXBT eddy search or survey	~ 10 hrs
17 May	Thursday	AXBT eddy search or survey	~ 10 hrs
24 May	Thursday	AXBT eddy search or survey	~ 10 hrs
5 June	Wednesday	AXBT eddy survey	~ 10 hrs
11 June	Monday	SUS (Appendix A)	
13 June	Wednesday	AXBT eddy survey	~ 10 hrs
15 June	Friday	SUS (Appendix A)	
19 June	Tuesday	AXBT eddy survey	~ 10 hrs

*Note to Op Services: These dates can be shifted around for your convenience. Our requirements are that the April flights be near the end of April.

E. Route/Flight Profile

AXBT Operations:

Limits of the overall operating area for FREDDEX are shown in Figure 1. Spacing of AXBT drops will be 30 nm in the North-South direction. An interval spacing in excess of 40 nm would seriously degrade the data. The altitude at which drops are made is left to the discretion of Op Services. Our bias is that we should attempt to minimize failure of the AXBT probes (due to impact forces, for example).

In the event that candidate eddies have not been selected prior to FREDDEX aircraft ops, it will be necessary to carry out an eddy search operation. Based on historical data, the most likely region to find eddies of the type desired is indicated in Figure 2. This figure shows an "eddy lane" approximately 100 nm in width which runs parallel to the mean position of the Gulf Stream. Eddy search operations would involve AXBT measurements to cover "eddy lane". The type of flight tracks to cover "eddy lane" are shown in Figures 3 and 4.

Although allowance is made for eddy search operations, it is hoped that a few eddies will be located prior to these air ops by other means. In this case, FREDDEX air ops will involve eddy survey operations to gain information on the location and shape of already selected eddies.

Eddy survey operations will involve AXBT drops to cover approximately a square region which is centered on the eddy. The type of tracks is shown in Figure 5.

F. Installation Requirements

It is requested that the Litton Inertial Naviation System be installed.

An AXBT recording system will be installed.

G. Test Flight Requirements

None

H. In-Flight Requirements

AXBT operations:

Op Services is requested to provide one man to launch the AXBTs.

A navigation log is needed. The log should contain the following information for each AXBT dropped: DAY, TIME, SEQUENTIAL NUMBER OF THE AXBT DROP, LATITUDE, LONGITUDE. The navigation log will be turned over to the project engineer at the conclusion of each flight.

The project engineer will mark the temperature plots for identification purposes. Also, he will maintain a plot of temperatures at 300 m depth so that a contour plot can be hand-drawn. The contours will be isotherm shapes at 300 m depth (see Figure 6). The utility of the contour plot is that it serves as an estimate of the eddy center and shape. It will be necessary to communicate certain parameters based on the contour plot to the USNS LYNCH. A decision as to the best parameters is yet to be made, but one possibility is shown in Figure 7. In this figure, the locus of the maximum horizontal temperature gradient at 300 m is sketched. Parameters that would be useful to the surface ship are the coordinates (lat and long) of the four points marked by crosses in the figure.

I. Pre/Post Flight Requirements

An important pre-flight requirement for the project engineer is to check into the possibility of replacing the standard recorder in the AXBT system with an x-y plotter in order to gain a better plot output from the system.

Further preflight requirements on the project engineer are to insure that the AXBT system is available and in working condition. Extensive communication with the Operational Services Group is also required before the flights to keep that group informed of any modifications that may arise.

After each flight the project eneineer will collect the temperature data and navigation log. These will be kept at NRL for later analysis.

An important post-flight requirement that may arise is the communication of eddy parameters to the USNS LYNCH: see (K) Communication Requirements.

J. Special Equipment Required

We have already mentioned that the primary piece of equipment will be an AXBT recording system and associated sensors. We estimate that approximately 60 AXBT probes will be used on 7 flights, thus indicating a need for 420 AXBT probes. Operational Services is requested to obtain these as soon as possible.

We are contemplating the modification of the plotter associated with the AXBT system.

K. Communication Requirements

It is required to communicate eddy parameters to the surface ship making oceanographic measurements--the USNS LYNCH. This may be attempted toward the end of each of the AXBT flights in June. However, it seems undesirable to consume flight time merely in order to accomplish such a communication. Therefore, if air-to-ship communication is not feasible, the eddy parameters will be communicated to the USNS LYNCH via NRL shore-to-ship radio on the day following each of the June AXBT flights.

L. Storage Requirements

Approximately 60 AXBT probes will be stored on the P-3 for each of the AXBT flights.

Some 420 AXBT probes will have to be stored at the PAX River station.

M. Weather Restrict ons/Requirements

Apart from standard requirements for flight safety, we have no special restrictions.

N. Number of Project Personnel on Flights

At this time the project engineer is the only member of the project who will be present on the flights. It may develop that one or two other scientists may desire to go on a (single) flight in order to gain some experience with the nature of airborne operations.

O. Other Information of Significance

The airborne operations are part of a multi-platform experiment and therefore it may be expected that as additional information is received from other parts of the program some adjustments may be necessary in the FREDDEX air ops.

For example, we expect important data to be collected in March which will have a significant impact on the air ops.

P. Ground Support Requirements

The project engineer will assess the need for ground support requirements and inform Op Services.

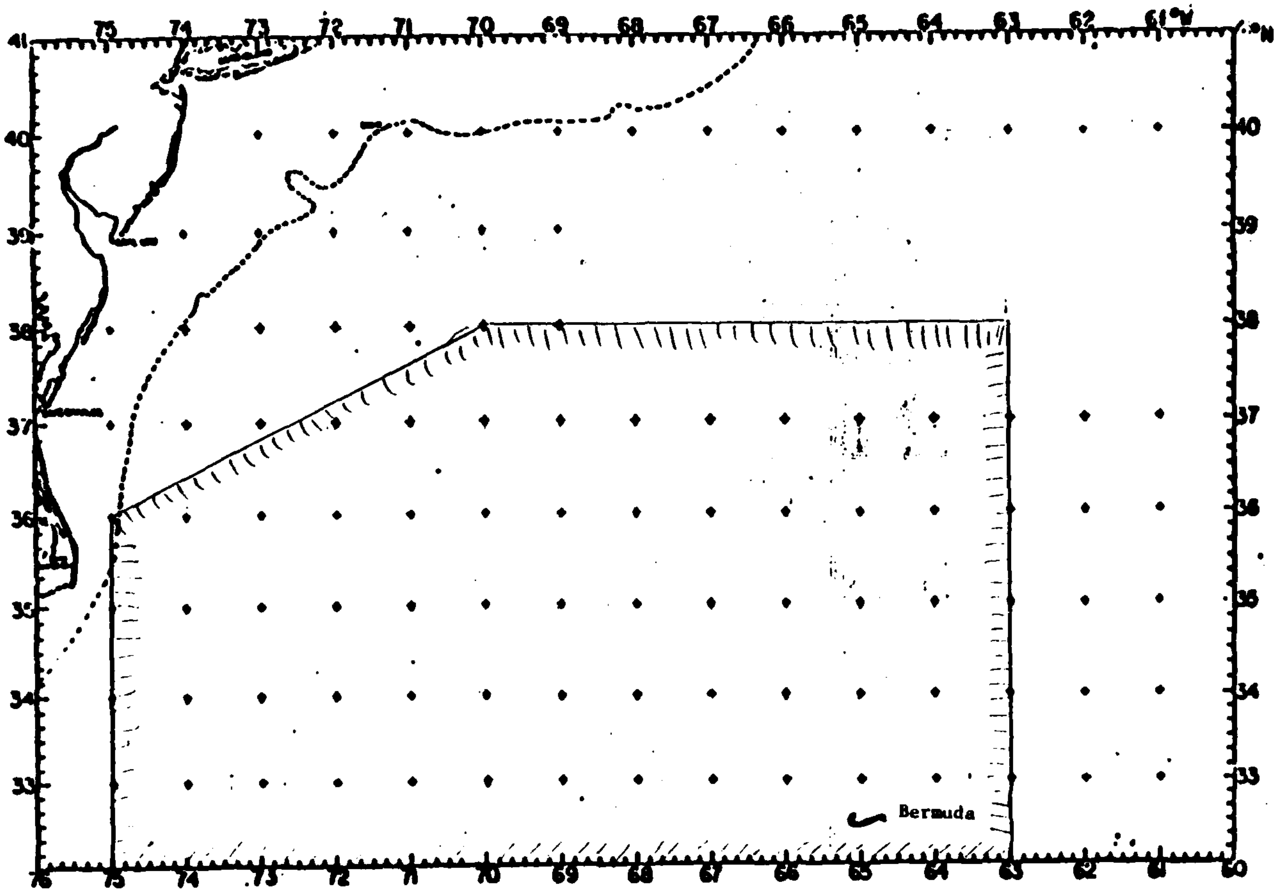


Fig. 1 - Limits for FREDDEX Aircraft Operations.

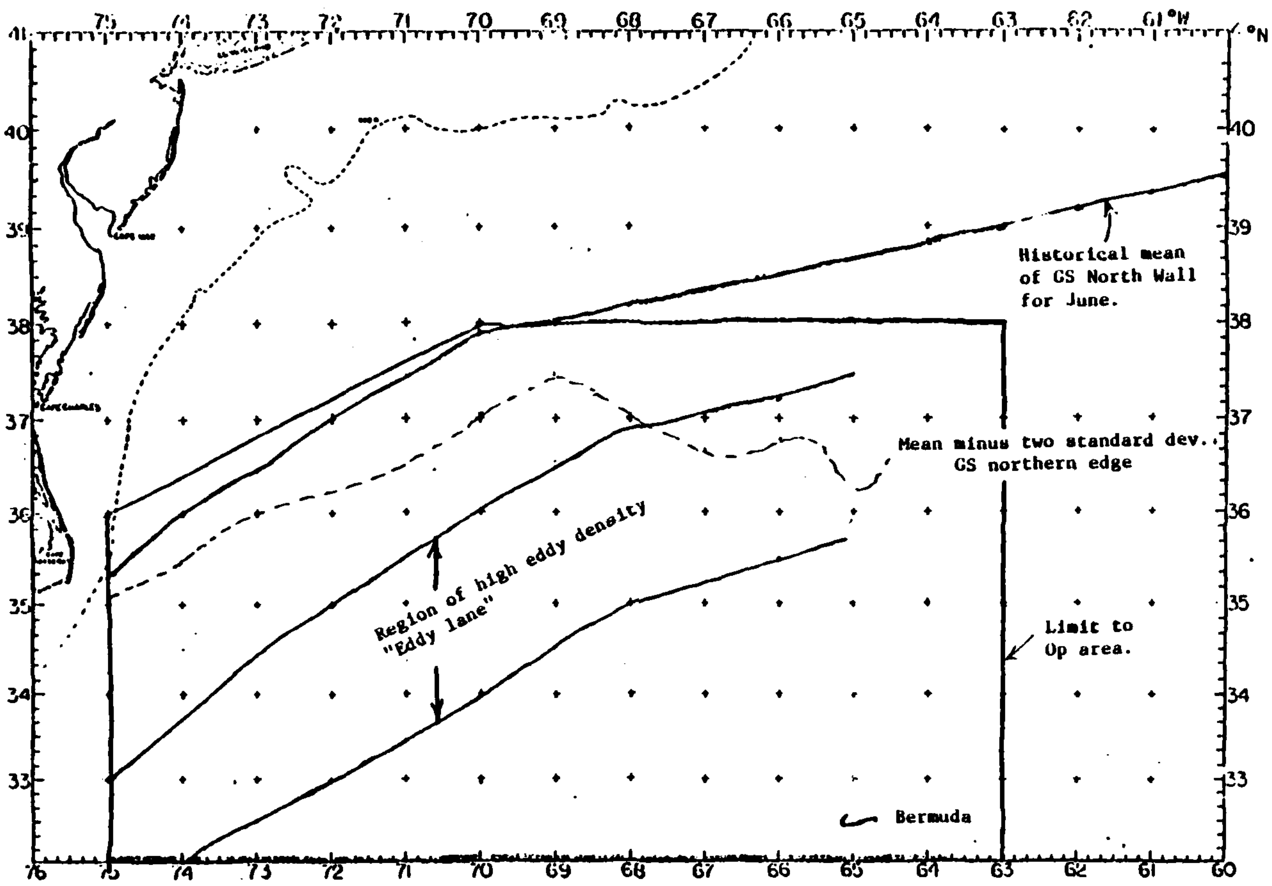


Fig. 2 - Region of High Eddy Density.

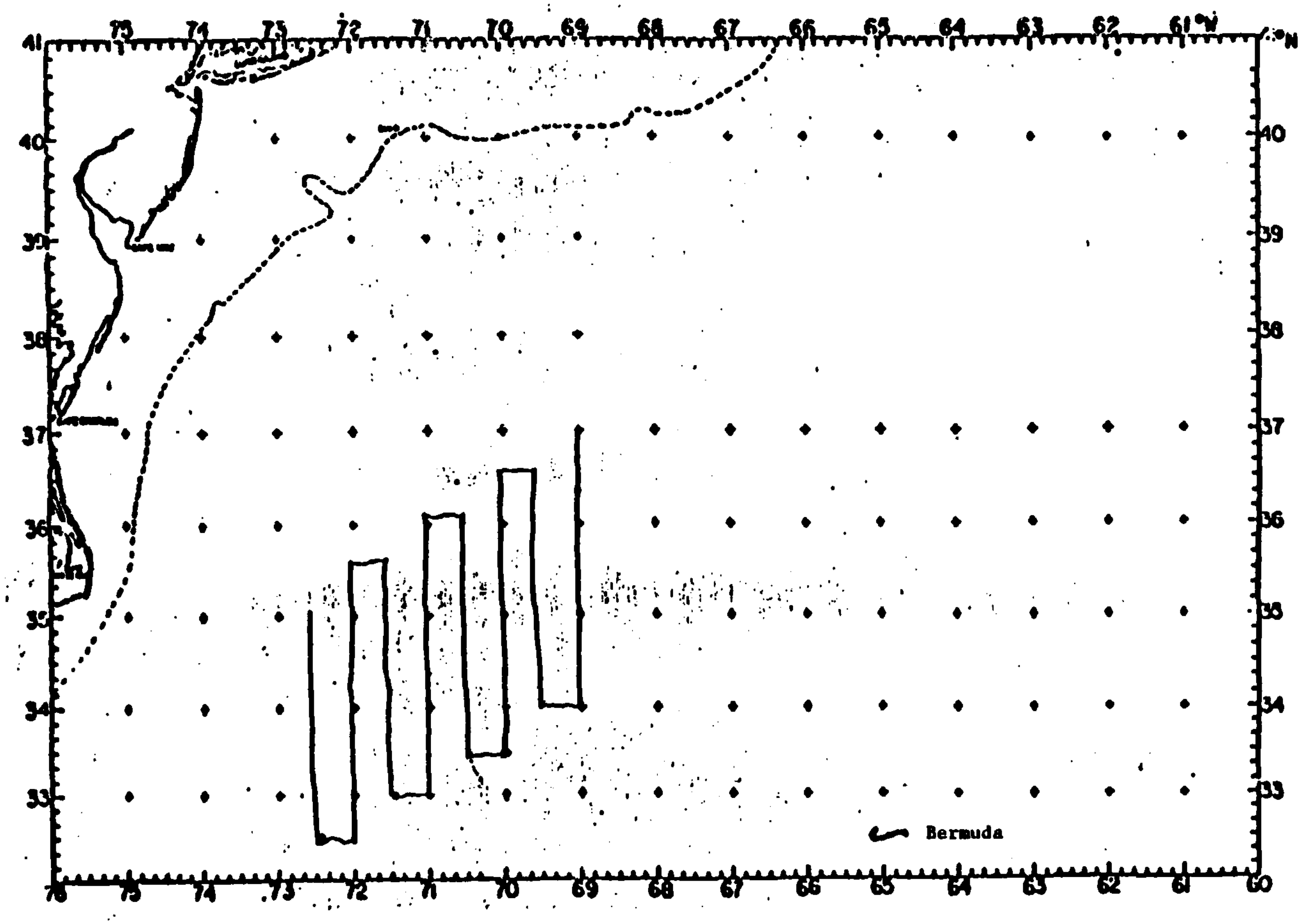


Fig. 3 - Flight Track for Eddy Search (AXBT Drops at ½ °' Increments Along North--South Tracks).

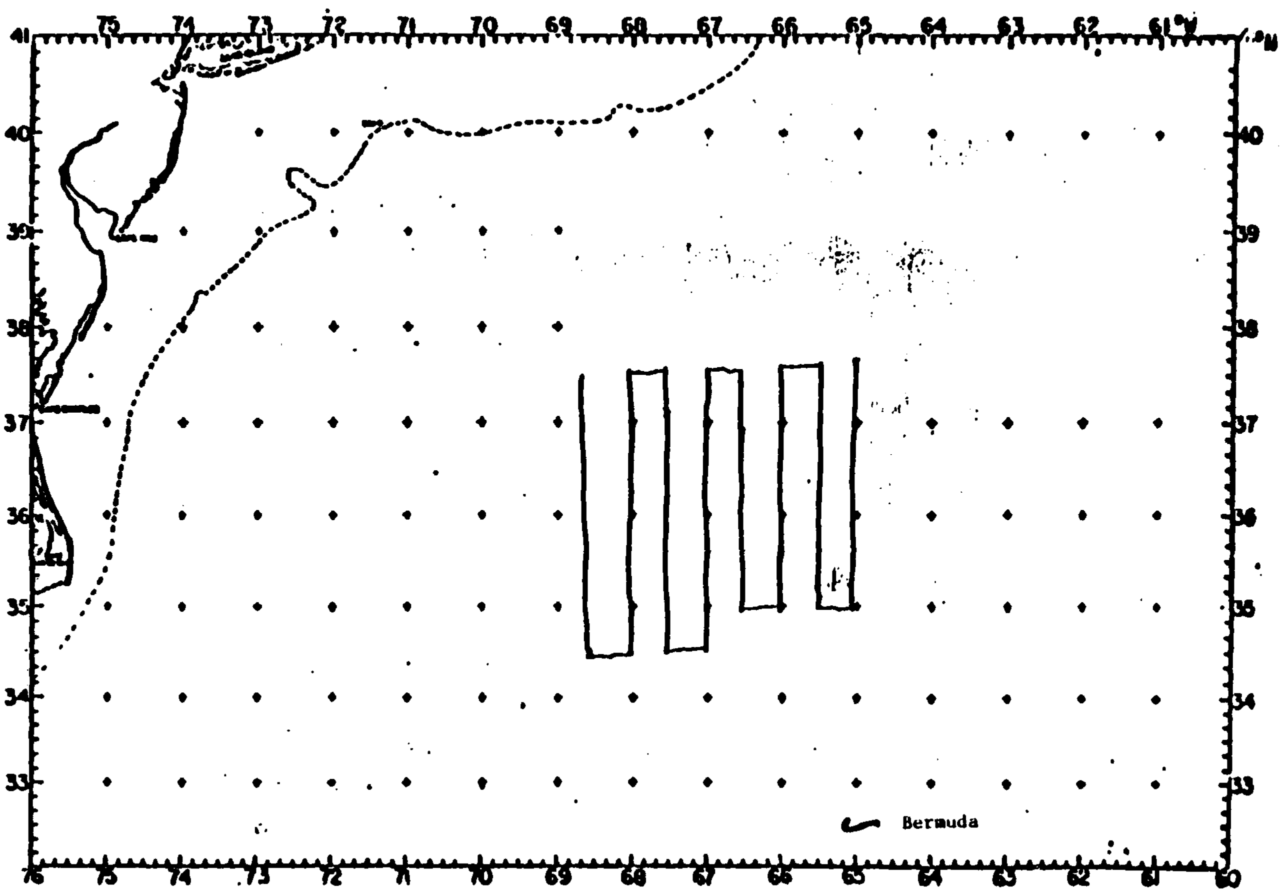


Fig. 4 - Flight Track for Eddy Search (AXBT Drops at ½° Increments Along North - South Tracks).

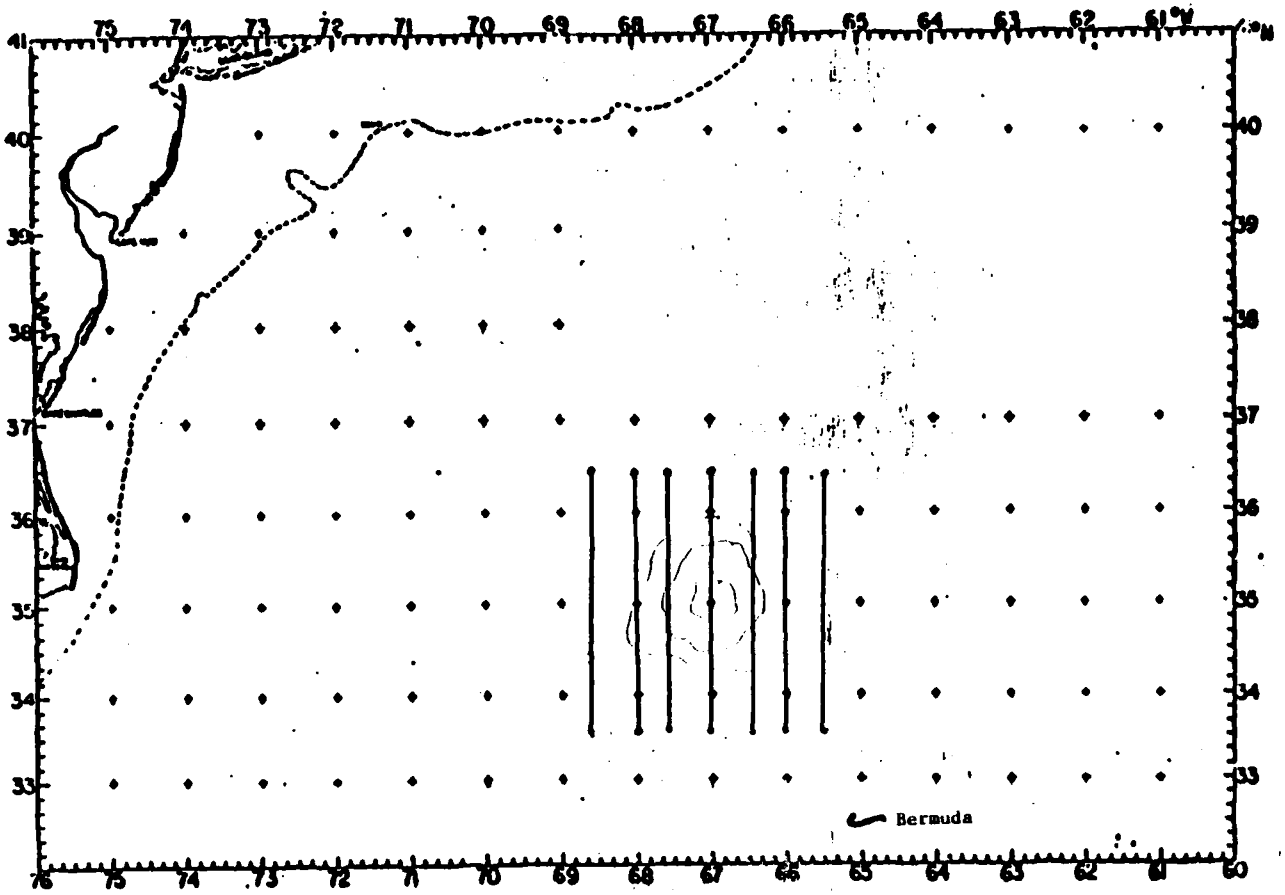


Fig. 5 - Flight Track for Eddy Survey (AXBT Drops at ½° Increments Along North--South Tracks).

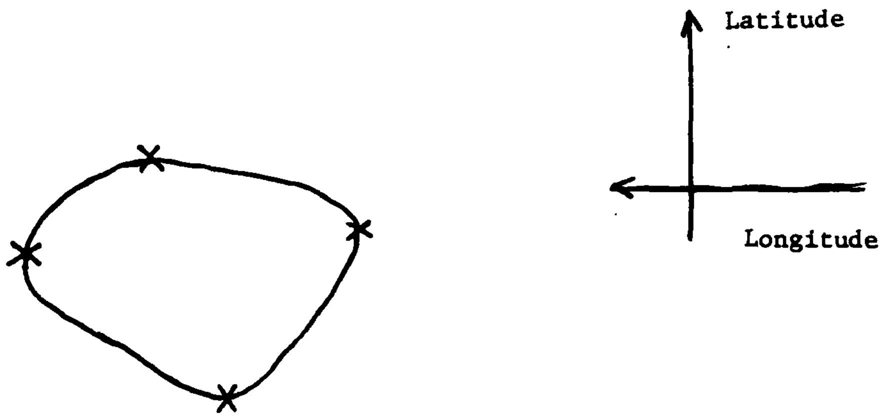


Fig. 6 - Type of Contour Plot of Temperatures at 300 m Depth

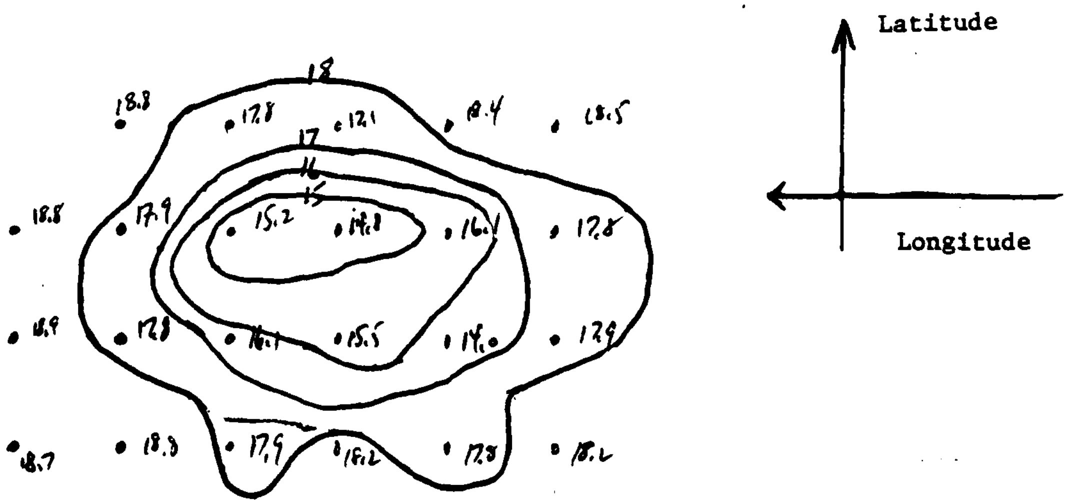


Fig. 7 - Locus of Maximum Horizontal Temperature Gradient Based on Temperature Contours in Fig. 6. The Maximum North, South and East, West Points on the Locus are Indicated by crosses.