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THE SEARCH FOR THE UNITED STATES REVENUE CUTTER BEAR

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SCIENTIAE CEDIT MARE

The Report of an Interdisciplinary Team of Cadets and Faculty Advisors

Cadets

S. Glynn
P. White
D. Gosselin
M. Fitzpatrick
J. Cline
M. Inman
L. Johansen
J. Butler
J. Cronin
D. Streyle
D. Riehm

Advisors

LCDR G. Keary
CDR B. Skinner
CDR D. Sandell

SEARCH FOR THE USRC <u>BEAR</u>

ACKNOWLEDGEMENTS

The Search for the USRC BEAR team would like to give special thanks to Harold "Doc" Edgerton, Professor Emeritus at MIT, for his inspirational leadership of the project. He made it all possible and rewarding. The assistance of Mr. Charles Miller, also of MIT, was invaluable as well.

Appreciation is expressed to those within the Coast Guard for their contributions to the program: LCDR O'TOOLE and the officers and crew of the CGC CONIFER; the Commander, Fifth Coast Guard District; the Commander, Atlantic Area; the Coast Guard Research and Development Center; the Superintendent of the Academy; the Dean of Academics; Associate Professor P. Johnson, LCDR COLBURN, CDR HASSARD, CDR HOTCHKISS, LT BOHAN, and LT NEAS.

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I. INTRODUCTION

A. ABSTRACT

Since the side-scanning sonar was first introduced to the scientific community in the mid-1960's, it, and the search techniques used with it, have seen continual re-development and refinement. The search for the U.S.R.C. BEAR represents another plateau in this process. The sophisticated electronics used in this effort have brought unparalleled accuracy to an underwater search employing a single surface ship.

This report includes a complete discussion of the use of the new micro-C.P.O. LORAN-C systems, and a practical guide for integrating them into underwater search. Analyses of search pattern construction techniques, the utilization of videotape documentation, and the managerial considerations inherent in scientific expeditions, are also included.

B. A SHORT INTRODUCTION TO THE U.S.R.C. BEAR

The auxiliary barkentine BEAR was built in 1874 by Alexander Stephens and Sons to serve in the sealing trade. In 1884 she was purchased by the U. S. Navy to take part in the rescue of the Greely Expedition. Following this adventure she was transferred to the U. S. Revenue Cutter Service to patrol the Alaskan coastline. The Revenue Service, parent organization of today's Coast Guard, put her to steady use for forty-two years breaking ice, providing medical assistance to the eskimos, enforcing and administering the law, and saving lives and property in the wild and unpredictable Northland. In 1929 Admiral Richard E. Byrd purchased the BEAR for his Antarctic ventures; and in 1941 he turned her over to the Navy for patrol duty in World War II. Following the war she was stripped and sold for scrap to a Nova Scotian firm.

It was in Nova Scotia that Alfred Johnston purchased the BEAR, intending to make her into a restaurant in his native Philadelphia. The tug IRVING BIRCH, Captain Chisholm commanding, left Halifax harbor on Sunday, 17 March 1963, with the BEAR in tow, and headed for Philadelphia. Two days later, 19 March, the BEAR was foundering in twenty foot seas; the towline parted and water came pouring in through uncaulked seams in her hull. Both the U. S. Coast Guard and the Royal Canadian Air Force directed units to assist the BEAR; a CG HU-16E (CGNR7227) and a Canadian C-47 (VC258) arrived on scene some time later. Neither aircraft, however, could be of assistance, and the <u>BEAR</u> ended her gallant career in stately dignity; beneath the waves.

C. PRELIMINARY RESEARCH

Beyond this general description of the BEAR's sinking, as previously mentioned, the published accounts give a wide variety of details; some quite contradictory. The focus of the preliminary research sought to clarify the important details, and answer these three basic questions:

1. Where did the BEAR sink?
2. When did the BEAR sink?
3. In what condition are we likely to find the BEAR?

To determine the answers to these questions one immediately recognizes an obvious historical source: the people on scene. A secondary, but possibly very detailed account might also be obtained from the insurers. No information was available from the Canadian aircraft, and the log of the USCG HU-16E had been disposed of. CDR E. L. Rahn, USCG Ret., and his co-pilot, CDR Paul L. Lamb, USCG Ret., were able to provide some information. Both pilots referred to William Bixby's book, Track of the BEAR, as containing the position where the BEAR sank: 42°25'N 65°35'W. CDR Rahn also indicated that this position was established by his flight and was probably accurate within five miles, and no more than ten miles off. The HU-16 was navigating by "dead reckoning" that day, "supported by very few, and poor, LORAN-A signals after leaving the coast." CDR Lamb, in his letter, supports CDR Rahn on these points; and is his contention that IRVING BIRCH was not at the position she reported herself at, but some 40 miles SSE. CDR Rahn's letter of 19 March

1979 and CDR Lamb's of 26 March may be found in the appendix.

The skipper of the IRVING BIRCH, a man named Chisholm, was contacted by telephone. He suggested that the tug's log be obtained, assuming that this log is extant. This log was not found for the search. Captain Chisholm said that he remembered the BEAR sinking about 2000 because it was at that time her running lights disappeared from view. He could not say, though, that he actually saw the BEAR sink. The winds, as he recollected, were from the northwest and the seas were quite rough which agrees with the CG pilots' accounts. He could supply no information on the state of the BEAR as she sank, nor did he have any explanation for the discrepancy between the position he reported, and where he was actually found.

The BEAR was insured by Prize, Forbes and Company, Ltd., at Lloyds of London which has, since 1963, been absorbed by Sedgwick, Forbes, Bland and Payne, Ltd. In response to an inquiry of 15 April, they replied on the 26th that all records concerning the BEAR had been destroyed.

One profitable source of information was uncovered through an offhand suggestion made at one of the team meetings. This was the recommendation that U. S. Navy submarine service records be investigated to see what information they might contain on wrecks (insofar as they are hazards to submarine navigation). Upon further investigation it was found that the Navy did indeed chart wrecks, and had produced a LORAN-C overprinted chart showing the wrecks on Brown's Bank (our search zone). Later, a Navy publication was found which listed one of the wrecks noted on the chart (above). This wreck is just off the bank in a submarine trench and is identified in this publication as the "Schooner BEAR." The source of this information was given in the publication as Canadian.

At the conclusion of this background investigation the team was armed with sufficient information to begin the search. There were, however, some uncertainties and unknowns not fully accounted for (and so they remain, at present). The investigation produced no original sources, but had to depend on the memories of the participants for the position at which the BEAR sank, and other such particulars. The position obtained appears to represent the spot where the HU-16E found the BEAR, yet it could also have been where she actually sank (with the drift added in)--the pilots are unclear on this point. Also, one cannot say, for certain, just when the BEAR sank, nor is it known in what condition or orientation she sank.

If any further search for the BEAR is contempleted, it would be beneficial to make every effort to fill the gaps remaining from this (the first) investigation. In an intensive re-investigation of this sort, more positive information might be obtained from Canadian sources. If the log of the IRVING BIRCH (owned by the Atlantic Towing Company) is extant, it should be found and examined carefully for any details it may contain. So, too, should a study be made of any written account(s) held by the RCAF in connection with the flight of the C-47 aircraft which saw BEAR as she was foundering. One should also attempt a more careful study of Navy information sources; they have already proved invaluable, and more (and better) position data might be obtained from them.

As a final suggestion, it would be good to contact Alfred

Johnston, the last owner of the <u>BEAR</u>. Such an attempt was made near the end of the 78-79 semester, but it failed. Some caution should be exercised in communicating with Mr. Johnston since this affair was costly to him; yet, it would be good to find him and gather what recollections he has of what actually happened in March of 1963.

D. PROJECT HISTORY

The Cadet "BEAR project" began at the suggestion of Dr. Harold Edgerton, Professor Emeritus at M.I.T., that a team of cadets attempt to find the BEAR using the side-scan sonar he had engineered. A few months after presenting a fascinating lecture at the Academy, Dr. Edgerton approached Academy officials with this plan, and it was given to CDR D. Sandell (director of Academy research) to develop as a Mission Area Program for the first class. CDR Sandell approached the class of 1980 in January 1979 with the proposed summer '79 M.A.P., and solicited volunteers with the understanding that, at that time, no vessel had been assigned to participate in the search. Despite the apparent uncertainty in the viability of the project, thirty-five cadets signed up to participate in it. Out of these, a team of ten was chosen on the basis of their academic speciality and grade average. Three alternates were also chosen should any of the selectees be unable to complete the project. At their first meeting together the cadets were advised that they were to take a one credit, semester overload for which they were expected to do all the research necessary to begin the search. Accordingly, jobs were divided up among the thirteen team members. Historical research (see preceding section), equipment familiarization, information acquisition, and organizational refinement of the project were all accomplished in the next four months.

The team also had to find a suitable search platform before all this careful research and planning could be put to use. CDR Sandell sent a message informing the Atlantic Area command of the project and its vessel needs; and on the 14th of February received a reply that stated that the command was attempting to free a vessel for the search. On the 16th of February the Fifth CG District informed the Academy that it could supply a WLB for the project. By the end of the month, the search had been assigned to USCGC CONIFER, LCDR R. F. O'Toole commanding, for the 11-19th of July.

During this time the team also took advantage of Dr. Edgerton's invitation to go to M.I.T. and receive an informal lecture on the side scan sonar, and underwater search techniques. His wide-ranging experience in this was both informative and inspriational.

The next phase of the search proparation began once the team returned to the Academy from the Cadet Summer Cruise. The next two weeks were spent in awide variety of activities; the first being a familiarization with the sonar and Loran equipment being used in the search. The cadets went out into Fisher's Island Sound on Academy T-Boats to practice using the equipment on objects which the Coast Guard Research and Development Center had placed there for that purpose. Mr. Richard Walker, from the R&D Center, came aboard the T-Boat for the first couple of trips to instruct all hands in the peculiarities of using the side scan and interpreting its trace. LCDR Keary, who had replaced CDR Sandell as the project officer for this phase, showed the cadets how to make use of the sophisticated LORAN-C receiver and plotter they were to use. The cadets also took time to construct buoys for marking any submarine contacts they should find. Time was also used to take care of any other loose ends before the search was begun.

On the 10th of July the USCGC CONIFER docked at the Academy pier and all of the search equipment was loaded on board. The next day was spent installing and stowing all the gear, and by 1500 the ship got underway. The CONIFER transitted the Cape Cod Canal that night, and proceeded to the search area designated "Alpha," arriving there about midnight on the twelfth. Upon arriving at the center of this first search area, a datum buoy was dropped and the side scan "fish" was deployed. The sonar was found to be malfunctioning, and it could not be operated as planned. A stop-gap arrangement was rigged with the "fish" being towed alongside the CONIFER on a 50 meter cable. Because of this shortened cable length, the recorder had to be placed in the ship's office, and the cable lead through a porthole. This arrangement was used until the 150 meter cable was repaired--the 14th of July.

The cruise proceeded well after this initial setback. Other problems which the team faced were primarily in determining the areas to search--this is discussed fully in the results. After searching for approximately four-and-a-half days, the CONIFER headed back to Portland, Maine, to end the expedition.

1291 Beach Park Blvd.
Foster City, Ca., 94404
19 March 1979

Stephen E. Glynn, Cd. 2/c
U. S. Coast Guard Academy
New London, Ct., 06320

Dear Mr. Glynn:

It appears you may have undertaken the task of locating the proverbial "needle in the haystack" in attempting to find the remains of the CGC Bear. It is doubtful that any information I am able to recall will be of much use to you, but I will be glad to pass it along. The flight was made 16 years ago today and was not the most noteworthy of the thousands of SAR missions I flew during 20 years. If you need position accuracy of less than 1 mile I doubt there is anyone able to provide that information.

In the book "Track Of The Bear" by William Bixby, the position of the Bear's sinking is given as 42°25'N, 65°35'W, or due east True from Boston. I believe this position is the one established by our flight. The reported position of the tug Irving Birch towing the Bear was some 40 miles SSE of this position and I feel certain she was in error. Prior to our arrival on scene a Canadian plane had already started a search in the tug's reported position and had not located her. As we approached the area we were able to establish weak and intermittant radio communications with the Irving Birch. Although these radio signals were sporadic, they provided us with enough information to home in on the tug using the aircraft RDF equipment. Our primary method of navigation enroute the scene was DR supported by very few, and poor, Loran-A signals after leaving the coast. The entire flight was flown at low altitude and most of the time well out of reach of VOR, DME or Air Defense Radar range.

Our primary concern during the flight was the welfare of the persons on board the CGC Bear. The tug Irving Birch was extremely concerned about how they would pick the two people off the Bear. The winds were very strong, at least 35 to 40 knots with higher gusts, and sea conditions were quite rough. The tug was unable to approach the Bear without danger of doing serious damage to both ships. We were finally able to establish reasonably good radio communications with the tug. We then had her move upwind of the Bear and dropped a rubber raft with a long trail line over the tug. The raft was floated down to the Bear and the two persons taken off.

Since we were not concerned with accurately fixing the position, no attempt was made to do so. After the men were safely aboard the Irving Birch, we were directed to return. On the return trip we flew directly to Logan Airport at Boston to drop off pictures we had taken of the Bear. I remember nothing unusual on the return trip after taking departure from our reported position. Our penetration of the Air Defense Identification Zone and our ETA at Boston I feel were all well within normal limits. Our reported position was probably accurate within a 5 mile radius and certainly within a radius of 10 miles. The CGC Bear, however, did not sink while we were on scene, but sometime later. There is some doubt in my mind that not even the Irving Birch was sure just when she did go down. She was still afloat and down by the bow when we departed. She was probably drifting South and East when we left and I have no way of knowing how many hours she drifted before she went to the bottom.

Good Luck with your project. I would be interested in hearing what progress you are able to make. I would certainly be interested hearing if you are able to locate The CGC Bear. At various times in my career people turned up who had been connected with the Bear. In my files I have a photograph of a picture of the Bear done in cement by Capt. Frank Curry in Kodiak, Alaska. At the time he did this picture he was approximately 90 years old and it is well done. The original picture is quite impressive, some 4' by 5', and I assume is still located in Kodiak.

Sincerely,

Edwin L. Rahn

Edwin L. Rahn
CDR, USCG, Ret.

Date: 26 March 1979

he desk of: Paul L. Lamb

To: Jean M. Butler

Subject: USCGC BEAR

I am excited about your project and will be pleased to give you whatever information and/or assistance that I can. On 19 March 1963, HU16E CGNR 7227 was diverted from a training flight in the vicinity of New Bedford, Mass. to assist the tug Irving Birch and the BEAR. The total flight time was 6.7 hours The pilots were Lt. Edwin L. Rahn and myself. (This information from my flight log book.) The aircraft and crew were stationed at CG Air Detachment, Quonset Point, R.I., under the operational command of CG Air Station, Salem, Mass.

The following information is based on my memory. Navigation was accomplished by loran-A. The actual location of the tug was by ADF. Two persons were aboard the BEAR. A raft was dropped upwind of the BEAR with a long trail line and it was retrieved by the two persons who then boarded the raft and were later picked up by the tug. The tug reported that it would remain on scene until control of the tow could be effected. CGNR 7227 departed the scene after it was ascertained that no further assistance could be provided. The seas were high - I estimate at least 20'. The wind at least 30 kts. with higher gusts from the North-northwest. The drift of the vessels was generally southward.

This information is from "TRACK OF THE BEAR" by William Bixby, David McKay Company, Inc. New York, 1965. "Not until the next morning did the crew learn via the local radio station that the BEAR had sunk. Her position, 42° 25' N. 65° 35"W, on a bearing from Boston of 090 True."

The BEAR was still afloat when we departed the scene. I do not know how the reported position of the sinking was ascertained, but I assume it was reported by the tug IRVING BIRCH. As far as I know, there was no other unit,, Coast Guard or otherwise on the scene after we departed.

I would like to be able to tell you that "I saw the BEAR sink in some particular position and I obtained an accurate fix", but that just isn't the case. I do hope that what I remember will be of some help to you, and I would be happy to cooperate in any way that I can toward the sucessful completion of your project.

Sincerely,

Paul L. Lamb

Paul L. Lamb
230 65th St. North
St. Petersburg, Fl. 33710

II. EQUIPMENT

A. LORAN-C

1. SYSTEM INTRODUCTION

The principal means of navigation used was LORAN-C, a hyperbolic electronic navigation system.

> A hyperbola is the locus of points, from which the difference of the undirected distances from two fixed pints, the foci, is always equal to a constant.

Using two electronic transmitting stations, a Master (M) and a Secondary (S), a hyperbolic grid of equal distance differences may be drawn as in Figure 2-A-1. Adding another secondary station will give a grid as in Figure 2-A-2. In LORAN-C chains, each master is grouped with two or more secondary stations, each with unique coding delays to allow receivers to distinguish between stations.

Geometric limitations inherent in this hyperbolic navigation system affect both coverage and fix position quality. These limitations may be resolved to two variables: crossing angle and gradient.

By observing Figure 2-A-2, it becomes evident that the

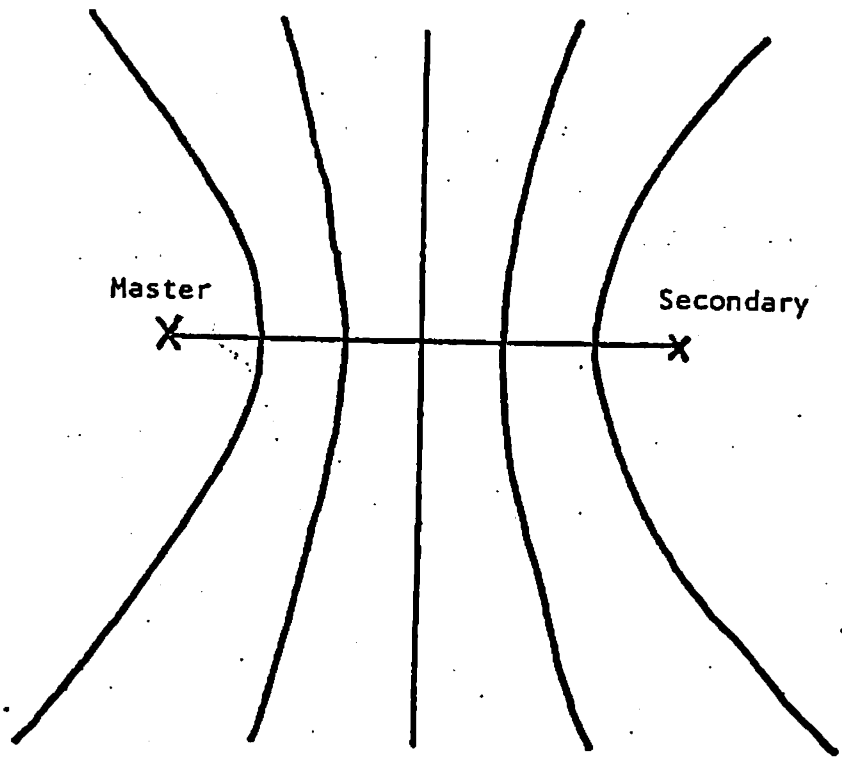


FIGURE 2-A-1

TWO-STATION HYPERBOLIC GRID

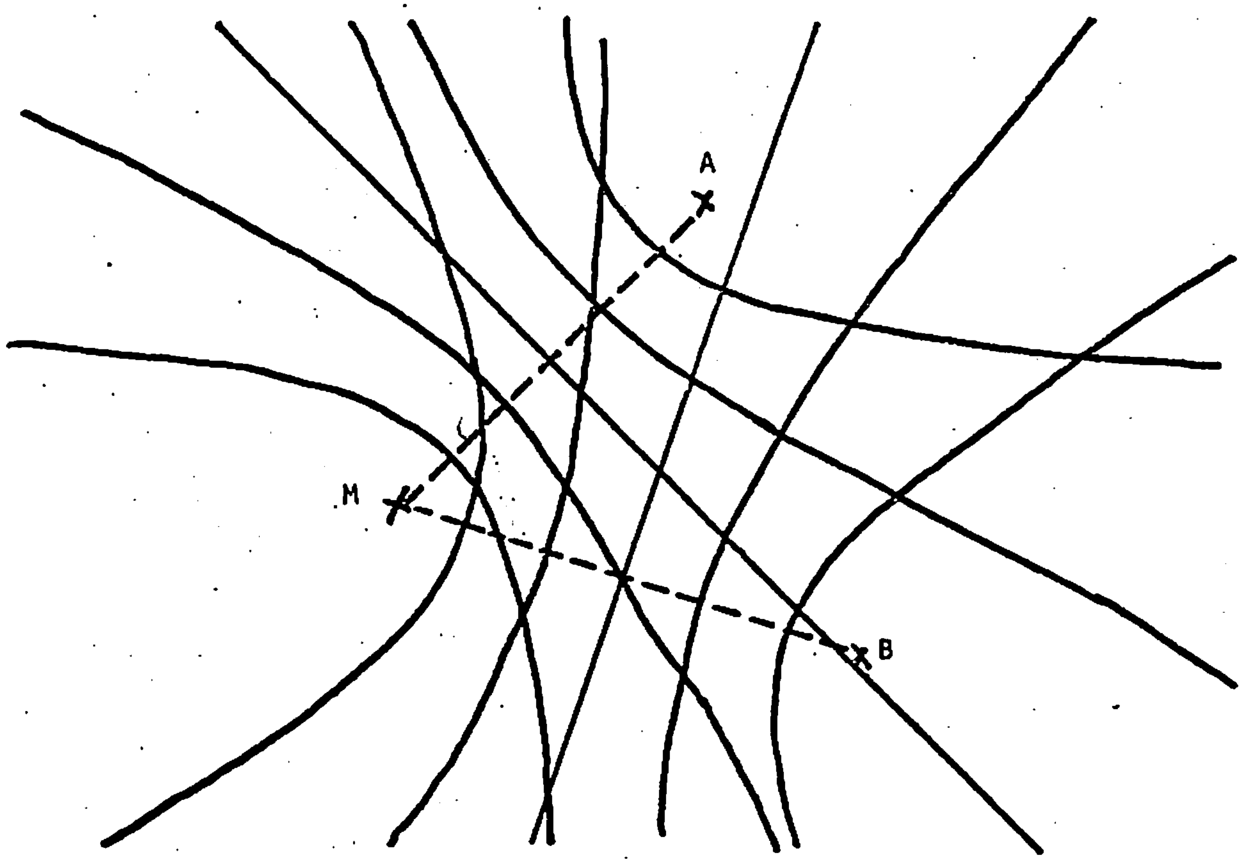


FIGURE 2-A-2

THREE-STATION HYPERBOLIC GRID

crossing angle between the two lines of position (LOPS) varies greatly within the service area. A drawing of the locus of points corresponding to where the crossing angles are 30°, 45°, and 90° is shown in Figure 2-A-3.

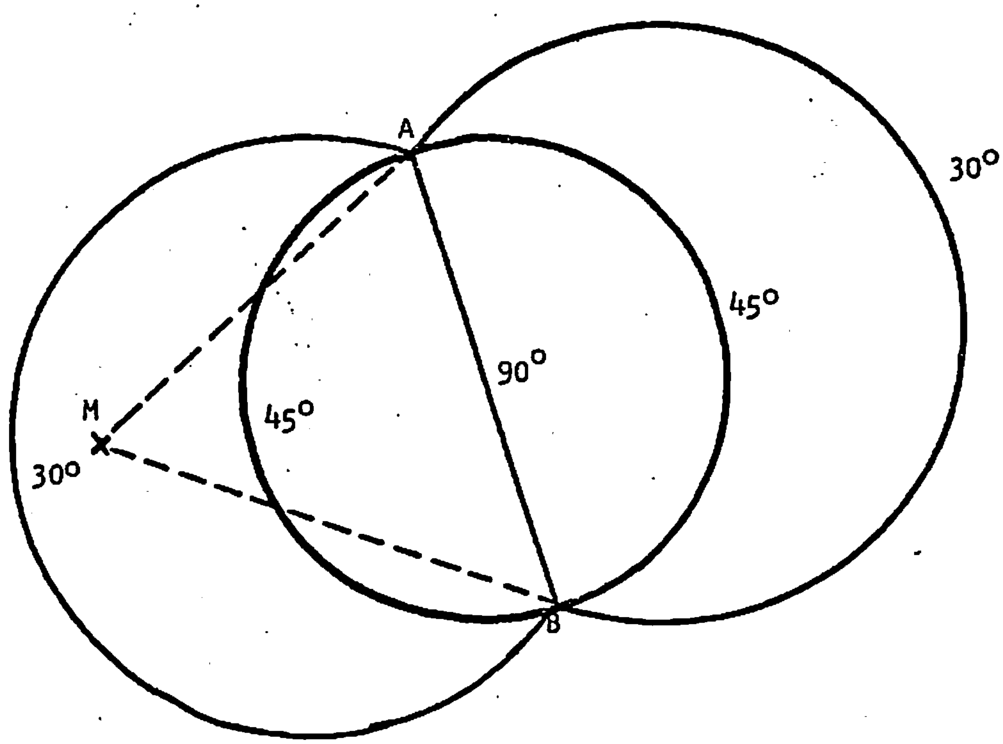


FIGURE 2-A-3
LOCI OF CROSSING ANGLES

The uncertainty of the fix position associated with the crossing angles is evident when the respective degree of precision of the LOP is drawn in as in Figure 2-A-4. The position of the

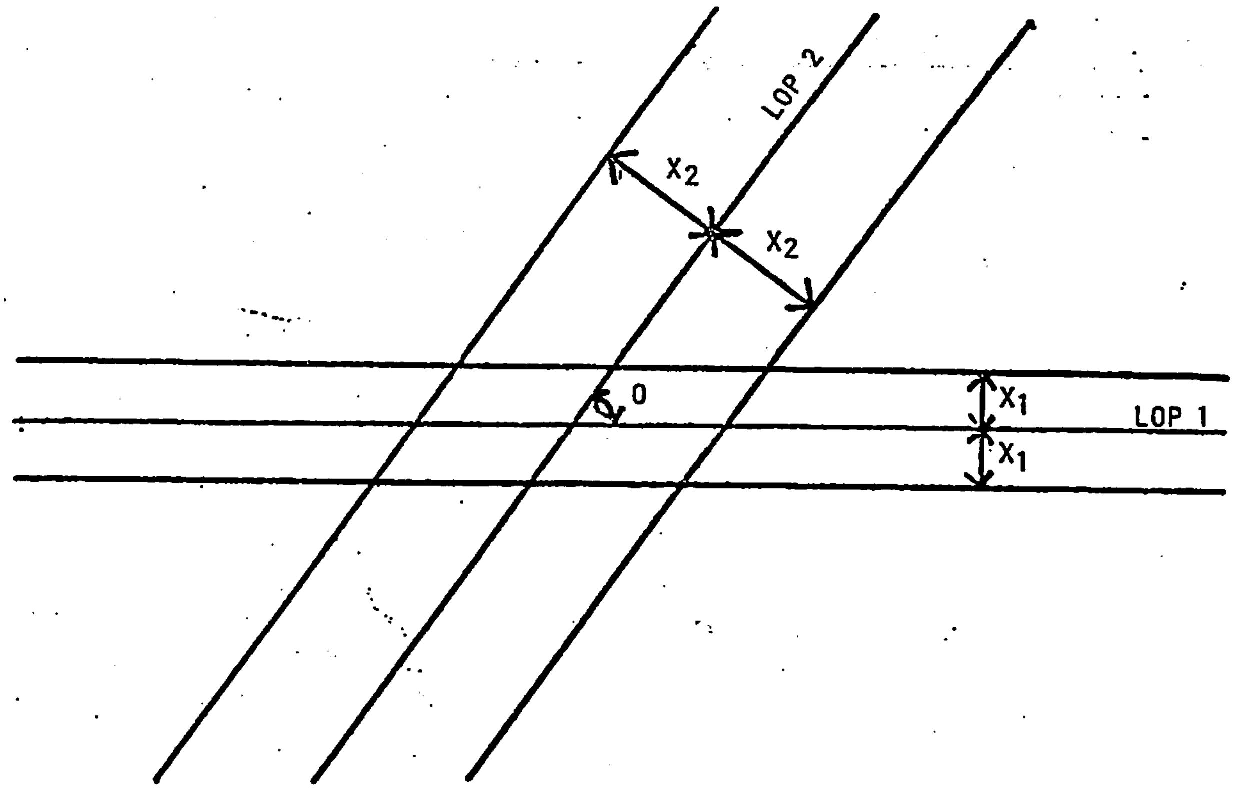


FIGURE 2-A-4
AREA OF A FIX

observer can be anywhere within the enclosed paralellogram. The enclosed area is:

$$\text{Area} = (2X_1)(2X_2)\ \csc\phi \quad \text{(Ref.2.)}$$

As the angle (ϕ) decreases, the cosecant function increases as shown in Figure 2-A-5. If the crossing angle is kept greater than 30^o, the multiplier is less than two. If the angle drops much less than 30^o, the area of the parallelogram will become very large.

The second geometric limitation is the magnitude of the gradient of eadh set of hyperbolic lines. This magnitude gives a relation of distance (feet) to time difference (micreseconds). As

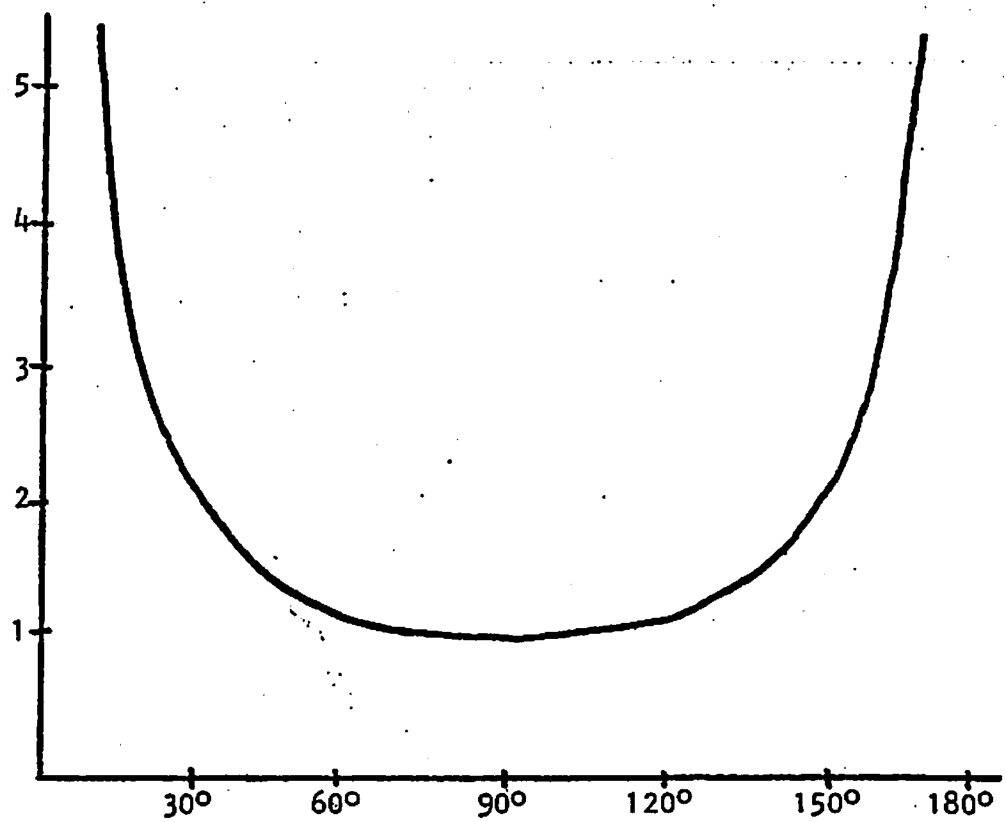


FIGURE 2-A-5
COSECANT FUNCTION

the magnitude increases the real distance between one microsecond time differences increases. The magnitude of the gradient is approximately given by:

$$/G/ = 491.62 \csc 1/2\ \Psi \quad (ft/\mu sec) \quad \text{(Ref. 2.)}$$

where Ψ is the angle, measured at the observer's position between the great circle directions to the master and secondary stations. The minimum is encountered along the baseline between the master and secondary stations and has a value of 491.62 ft/μsec. The values increase as the observer's distance from the baseline increases.

The effect of the gradient, in feet per microsecond, upon fix accuracy is found by changing the standard deviation of the LOP, in microseconds, to distances, in feet. Assuming that the standard deviation for both LOPs is 0.1 microsecond, the actual width of the uncertainty expressed in feet (found by multiplying the gradient by the standard deviation), could range from 46 feet to 200 feet within the coverage area.

A third, non-geometric, limitation to LORAN-C use is the strength of the signal transmitted with respect to the background noise, the signal to noise ratio (SNR). As the distance from the transmitting station increases, the SNR decreases to the point where a receiver cannot distinguish between the background noise and the Loran signals. The effective range of the system is then limited by the SNR.

Combining the three limitations given above, crossing angles, gradients and SNR, a coverage area or useable area for the chain is established. For the given triad, the coverage area is shown in Figure 2-A-6.

When describing the accuracy of the fix, three methods are commonly referred to: the probable parallelogram, the probable ellipse and circular error probable.

The probable parallelogram is defined as one for which the probability of the position being within the bounds is equal to fifty percent. The probability of the parallelogram with 1.0 standard deviations is 46.6%. In order to achieve the probable parallelogram, each side must be increased to 1.05 times the width

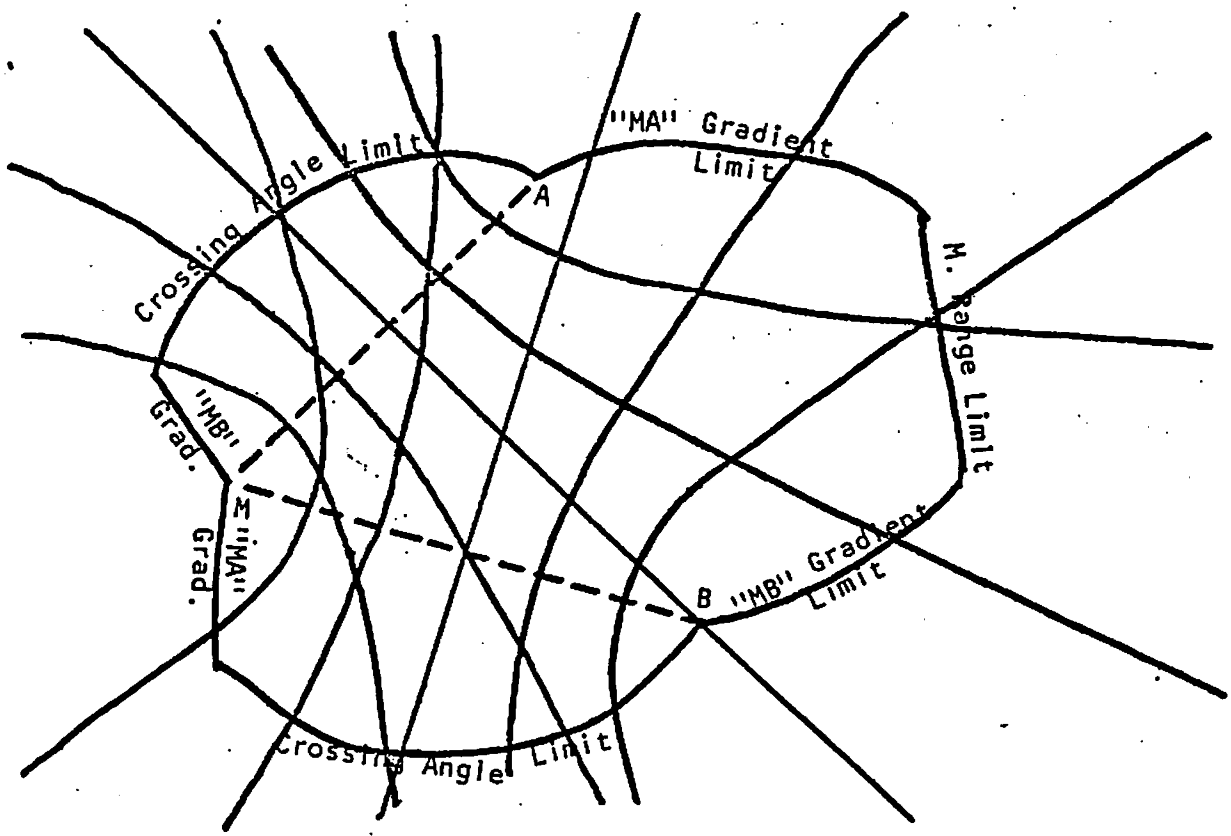


FIGURE 2-A-6

COVERAGE AREA FOR A TRIAD

2. NORTHSTAR 6000

The team used two Northstar 6000 LORAN-C receivers, each connected to separate 12-foot fiberglass whip antennas. This receiver has many useful functions for underwater searches, including memory, latitude, longitude, course, speed, steer a line, steer a point, time to go and SNR displays. All of these functions were used during the preparations and the actual search.

During normal operation, the receiver will display two time differences continuously and track up to five secondary stations. Another function normally used is displayed latitude and longitude in increments of degrees, minutes, tenths and hundredths of a minute. By changing the function to SNR, the SNR of the entered TD will be displayed. This is an advantage over most receivers that will only give a warning if the SNR is too low. It is useful in evaluation of the signal strength and reliability. Another change and the average course and speed over the last three minutes will be displayed. This is the speed made good and the course over ground.

By making another switch change, the receiver will memorize all of the above except the SNRs for retrieval at another time. The signals are still being tracked, but not displayed. This function was used for ease in recording data when a sonar contact was made. The data could be recorded in an organized manner instead of frantically writing down TDs before they changed.

Two other functions were useful in the search phase of the mission: steer line (STL) and steer computed line (SCL). The steer line is a function to follow a particular Loran line. The procedure to use for this search method is to steer to the desired Loran line and then change to the function. The display will give errors to the right or left of track in one-tenth of a microsecond increments. The display is shown in Figure 2-A-8. It is very useful when the tracklines are parallel to a set of Loran lines. An

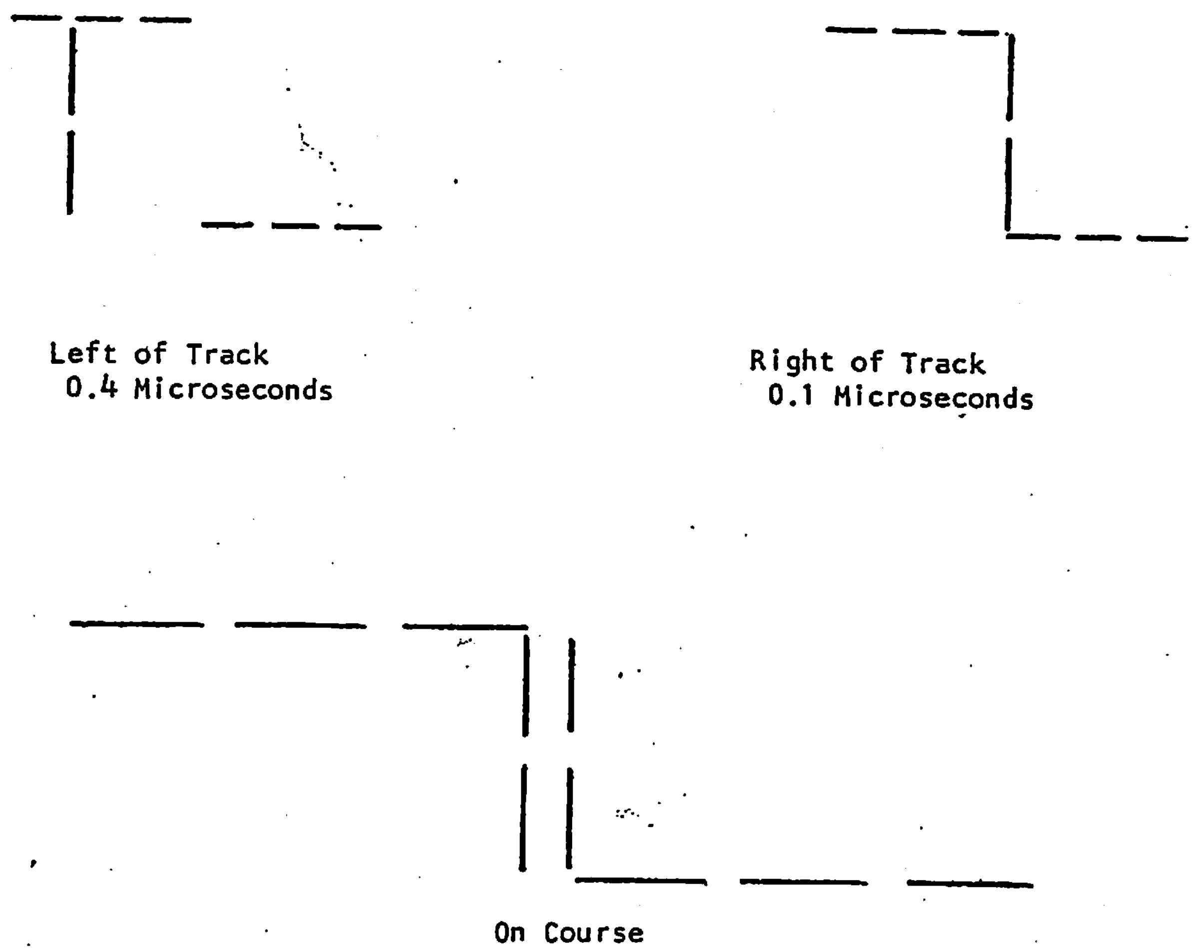


FIGURE 2-A-8

DISPLAY OF STL FUNCTION

additional feature of this function is the reverse (STLR) mode to give a realistic picture of the direction of swing, if the LOPs increase to the right of track instead of left.

A similar function to STL is the Steer Computed Line (SCL). This gives the same readout as above, except that the destination is entered as Loran coordinates and the line to steer is between the destination point and the ship's position at the time the point is entered. The coordinates are entered by switching to the Enter Computed Line function and stepping the flashing digits up or down with the toggle switch. This function was used to return to targets for a second look.

The reverse mode (SCLR) serves the same purpose as STLR, a realistic picture. However, two lines are now being used. The procedure for deciding whether to use SCL or SCLR is to take the LORAN-C chart of the operating area and place the LOPs with the smallest time difference increasing from bottom to top of the chart. Next, look at the other set of LOPs. If they increase from left to right, use SCLR and if they increase from right to left, use SCL. An example of SCL is given in Figure 2-A-9.

One last function of the Northstar 6000 is the Time To Go setting. This is used in conjunction with SCL or SCLR. It takes the distance to go and the average speed, and displays the time to go until the point is reached. The display is in hours, minutes and tenths of minutes. When the observer is within one microsecond of the destination, the display will change from the time to "close" and when the distance is less three-tenths of a microsecond, it will

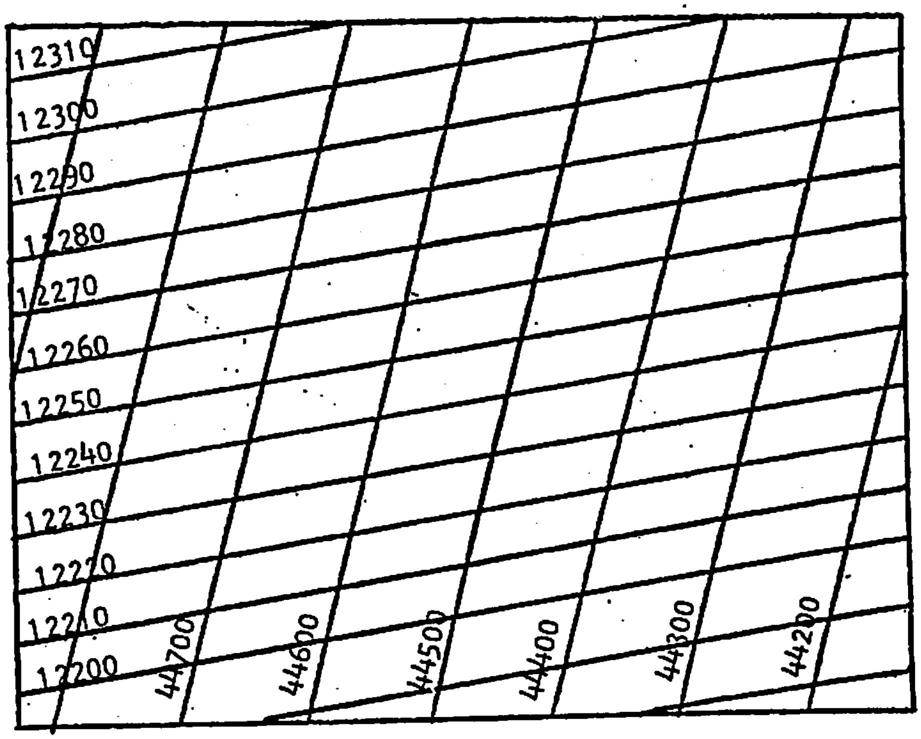


FIGURE 2-A-9

LORAN-C CHART FOR SCL

change again to "arrive." This function was found to be very accurate in returning to a target on the ocean floor.

During the search phase at Brown's Bank, the receiver was set to the Northeast United States Chain (9960 GRI) with the master station in Seneca, N. Y., and secondary stations in Caribou, Me.(w), Nantucket, Mass. (x), Carolina Beach, N. C. (y), and Dana, In. (z). In this area, the gradients for each were:

Mw	934	(ft/μsec)
Mx	2384	
My	1365	
Mz	7907	

The crossing angles and CEP for each pair are:

	Crossing Angle	CEP
Mw Mx	44°	262 (feet)
Mw My	53	158
Mw Mz	35	934
Mx My	9	1163
Mx Mz	8	3855
My Mz	18	1802

From this data, it can be seen that the two best lines were Caribou, Me. (w) and Carolina Beach, N. C. (y) because of their having the smallest gradients, the smallest CEP, and the greatest crossing angles. The signal strength of both were found to be adequate. At night, the Carolina Beach SNR dropped, but not enough to warrant changing to another secondary station for the primary data.

Overall, the system worked very well both in Fisher's Island Sound and at Brown's Bank. The repeatable accuracy and the ability to memorize and return to a point, made this receiver very useful in this underwater search.

3. EPSCO C-PLOT

The purpose of this section is to investigate the EPSCO C-PLOT and EPSCO C-PLOT 2 LORAN-C position plotters. The theory behind each plotter, the capabilities of the plotters, and the differences between the plotters shall be discussed.

The EPSCO C-PLOT is an X-Y plotter. By assuming that LORAN lines are straight in lieu of being hyperbolic the machine is able to employ two transforms that convert time differences in LORAN lines into actual North/South and East/West movement.

The following equations define the transformations used by the plotter:

$$\Delta \text{ east/west} = HC[SEC\ B]\ \Delta TD_A + HC[SEC\ A]\ \Delta TD_B$$

$$\Delta \text{ north/south} = VC[SEC\ B]\ \Delta TD_A + VC[SEC\ A]\ \Delta TD_B$$

where:

Δ east/west = pen movement left and right

Δ north/south = pen movement up and down

$HC[SEC\ A]$ and $HC[SEC\ B]$ are coefficients defining east/west (horizontal) movement

$VC[SEC\ A]$ and $VC[SEC\ B]$ are coefficients defining north/south (vertical) movement

ΔTD_B = change in time difference for secondary B

ΔTD_A = change in time difference for secondary A

In order to accomplish this task information such as time differences of the LORAN lines at the initialization point, scale of the chart, and slope of the LORAN lines must be entered into the machine manually.

The assumption that the LORAN lines are straight produces a negligible error on small area charts, that is, if the coefficients chosen are computed as per the C-PLOT operating instructions rather than using EPSCO LORAN-C Position Plotter Coefficient Tables. The plotter tables are compiled with the concept of producing no greater than a ten percent distortion on large area charts, and are therefore best suited for that purpose. It is more accurate, for a small area chart, to have the coefficients calculated from a LORAN-C chart.

The accuracy of each plot made by the plotter should be checked by comparing the azimuths drawn by the machine to the listing of EEE-10, the program used to plot LORAN-C lines on nautical charts. This procedure is imperative to insure accurate mapping.

The plotter receives Loran signals from the receiver and plots the actual course over the ground on the chart. The actual Mercator chart projection may be distorted due to the "straight line" assumption, but the repeatability of the machine is excellent. In other words, if the machine draws the plot on the chart driving through a buoy when in fact the vessel passed 100 yards off the buoy, by turning around and driving the ship so as to again drive the plot through the buoy, the vessel should again pass 100 yards off the buoy.

The plotter is equipped with two filters that help to "weed out" poor LORAN signals that might occur due to peculiar environmental or atmospheric conditions. The velocity filter instructs the plotter to ignore any inputs that indicate the vessel is travelling at a speed in excess of 50 knots. The running averaging filter uses the last 10 readings to construct the plot. The averaging filter causes a small delay in the plot position and may provide an inaccurate plot when turning. These filters may be engaged at any time so it is recommended that they only be used when conditions dictate (i.e., when obvious discrepancies appear on the plot).

The newer model, the EPSCO C-Plot 2 provides a more geographically accurate plot as well as maintaining the excellent repeatability of the EPSCO C-Plot. This plotter need not be interfaced with as technically sophisticated a receiver as the Northstar 6000, for it provides the same information as that receiver.

The plotter not only presents the graphics of the C-Plot, but may also be commanded to display the following on a digital readout:

1. Time differences of LORAN lines.
2. Latitude-longitude of the present position.
3. Bearing to a destination with respect to true North.
4. Distance to a destination in Nautical miles.

There are a few other benefits that go along with this plotter. The first is that no initial linear approximation for the LORAN lines is needed. This means that no coefficients for the slope of the LORAN lines need be computed. Also the machine can be initialized by entering a latitude and longitude rather than LORAN line time differences. Another improvement is the ability of the plotter to store in its memory up to nine destination points for the use of functions 3 and 4 listed above. An important aspect of the C-Plot 2 is that it plots the actual hyperbolic LORAN lines rather than straight line approximations. This is a great aid in geographical accuracy.

The C-Plot 2 has the same filters as the C-Plot Position Plotter (with the exception that the running averaging filter uses eight readings for a plot versus the ten used by the C-Plot) and should be similarly employed.

The C-Plot 2 was not used on this expedition as it arrived much too late. The machine was introduced just minutes before the search team departed. It was not used since its capabilities had not been fully investigated.

It is recommended that the C-Plot 2 interfaced with the Northstar 6000 be used for future searches. The reasons for retaining the Northstar 6000 are its abilities to simultaneously track five LORAN lines and to memorize all the LORAN lines and latitude and longitude at any instant of time.

B. SIDE SCAN SONAR

The instrument used to actually search the bottom was the EG&G Side Scan Sonar System. The system produces records of the topographic and geologic features of the bottom of a body of water. It does so by transmitting short bursts of high-frequency sound in fan-shaped beams to each side of the towing vessel. The echoes that occur when the sound pulses strike objects are processed and graphically recorded to produce a continuous acoustic picture of the sea floor. Details of the system's components and method of operation not contained in this report may be found in the instruction manual.

The side scan sonar equipment carried by the search team included the following parts supplied by the Coast Guard Research and Development Center: Recorder Model 259-3, Safe-T-Link Tow Fish Model 272, 50 Meter Shallow Tow Cable, 150 Meter Deep Tow Cable with Adapter Cord, Towing Depresser, paper for the recorder, and extra parts. In addition, Dr. Edgerton and Prof. Miller brought with them a recorder and tow fish (same models as above), 50 meter cable, and AC power supply. The team brought eight 12 volt marine batteries and a charger for its power source.

1. RECORDER

The side scan sonar recorder, which runs on a 24-30 volt source, is housed in a lightweight, fiberglass carrying case. This case contains the major portion of the system electronics, the graphic readout device, all controls and indicators, and an input power cable (Figure SSS1).

2. TOW "FISH"

The tow fish (Figure SSS2), connected to the recorder by a cable of three optional lengths (50M, 150M, 600M), contains two sets of transducers, the transducer driver and preamplifiers for received signals. Fallaway tail fins minimize the possibility of snagging the fish on an obstruction. The safe-t-link feature allows the fish to disengage itself from an obstruction by disconnecting the power cable and shifting the point of tow. The fish can theoretically be launched and retrieved by one person, but at least two were always used for safety reasons.

To produce the sonograph, the recorder uses dual helix electrodes which sweep out from the center of the recording drum (Figure SSS3). The port and starboard received signals are amplified and ultimately applied to the port and starboard helices of the graphic printer as a varying current. This current passes through the specially treated paper to the printer blade to ground. As the current passes through the paper, iron ions are formed on the paper producing marks of varied intensity (in proportion to the strength of the received signal) forming a graphic representation of the ocean floor.

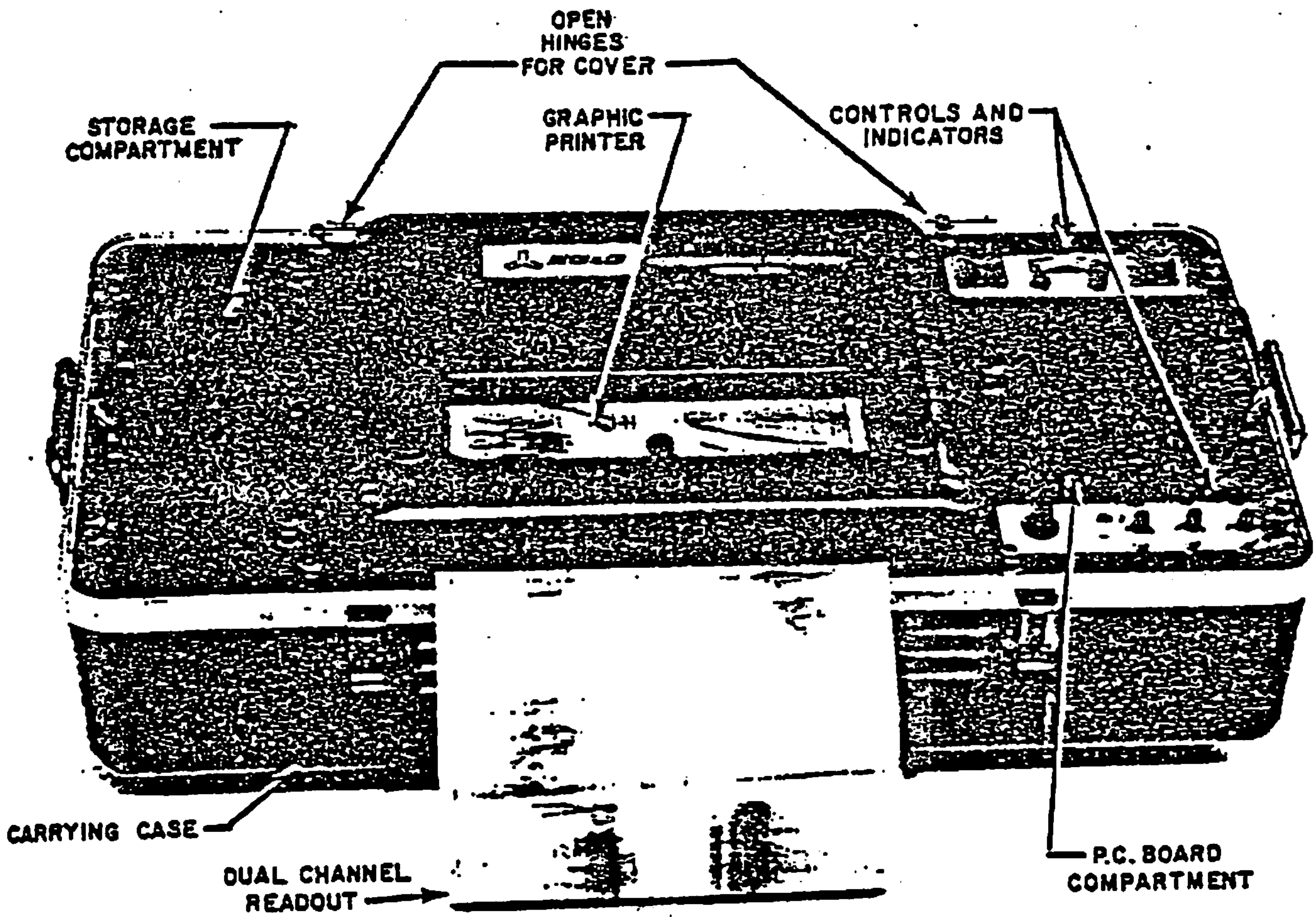


Figure SSS1. Model 259-3 Recorder

APPENDIX TO FIGURE SSS1

SIDE SCAN SONARGRAPH INTERPRETATION FOR USCGC <u>BEAR</u>

Length = 60.5 m

Beam = 9.1 m

Depth = 6.3 m

Scanning Range = 200 m

Fish Height = 20 m

Speed = 6 kts

$$L_s = \frac{H_t \times R_s}{H_f - H_t}$$

TERMS

H_t = height of object

H_f = height of fish

R_s = range of object

L_s = length of shadow

W_o = width of outline

L_o = length of outline

<u>Position #1</u>

R_s = 50 m

L_s = 23 m

W_o = 9.1 m

L_o = 20.2 m

R_s = 100 m

L_s = 46 m

W_o = 9.1 m

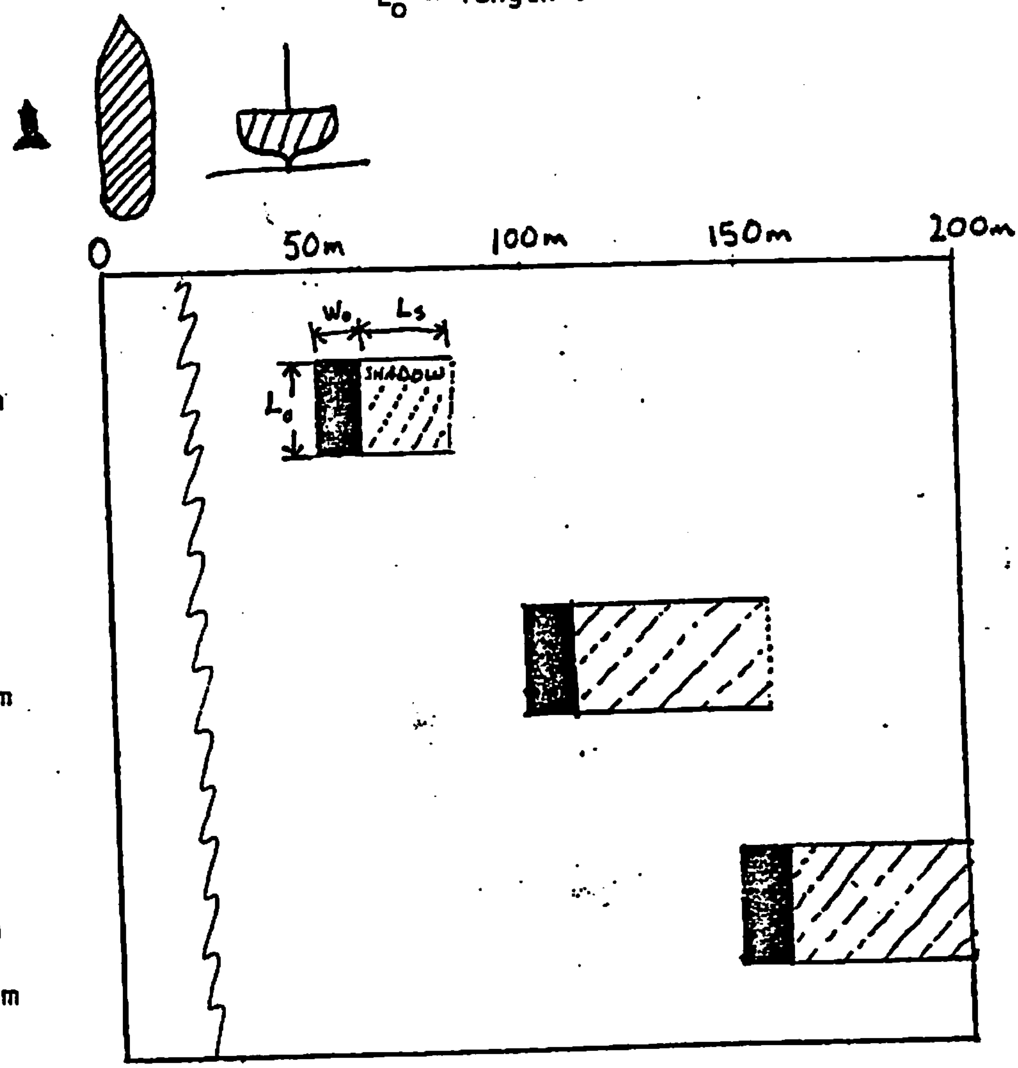
L_o = 20.2 m

R_s = 150 m

L_s = 69 m

W_o = 9.1 m

L_o = 20.2 m



SONARGRAPH INTERPRETATION

Position #2

R_s = 50 m

L_s = 41.7 m

W_o = 6.3 m

L_o = 20.2 m

R_s = 100 m

L_s = 83.5 m

W_o = 6.3 m

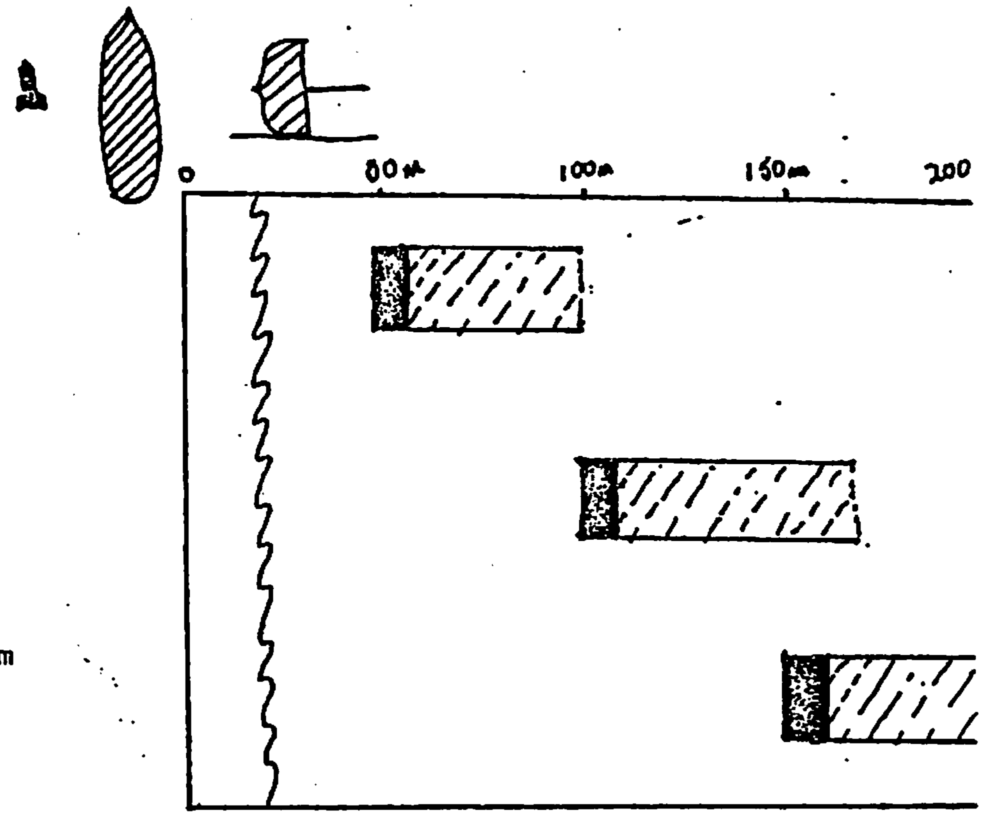
L_o = 20.2 m

R_s = 150 m

L_s = 125.2 m

W_o = 6.3 m

L_o = 20.2 m



Position #3

R_s = 50 m

L_s = 23 m

W_o = 60.5 m

L_o = 3 m

R_s = 100 m

L_s = 46 m

W_o = 60.5 m

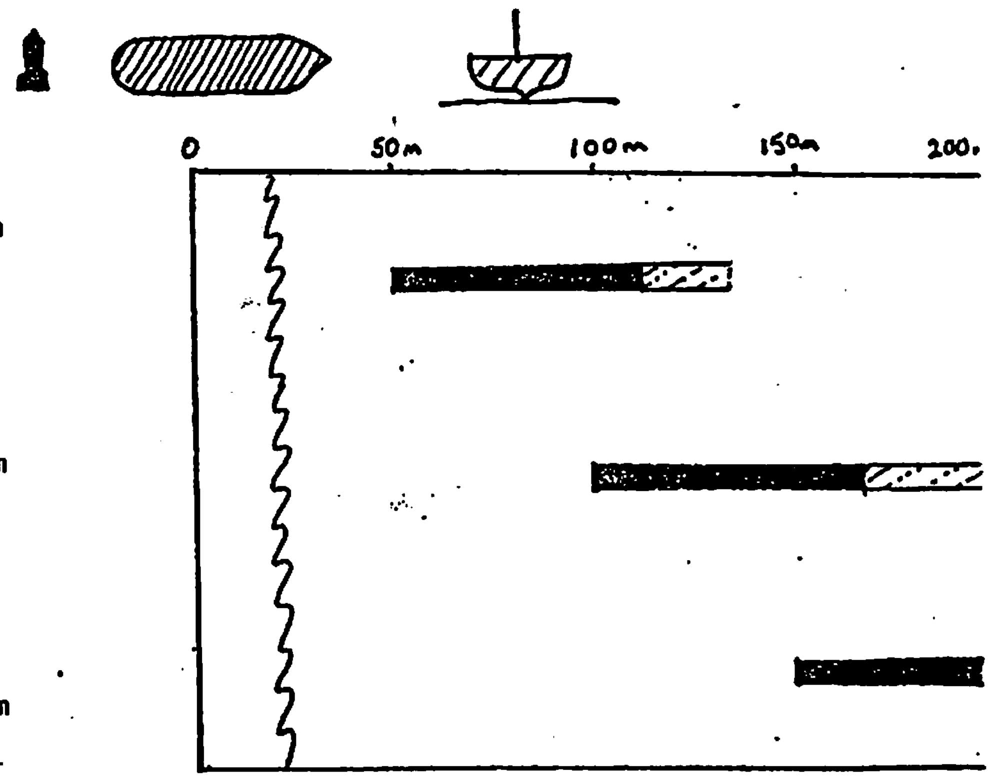
L_o = 3 m

R_s = 150 m

L_s = 69 m

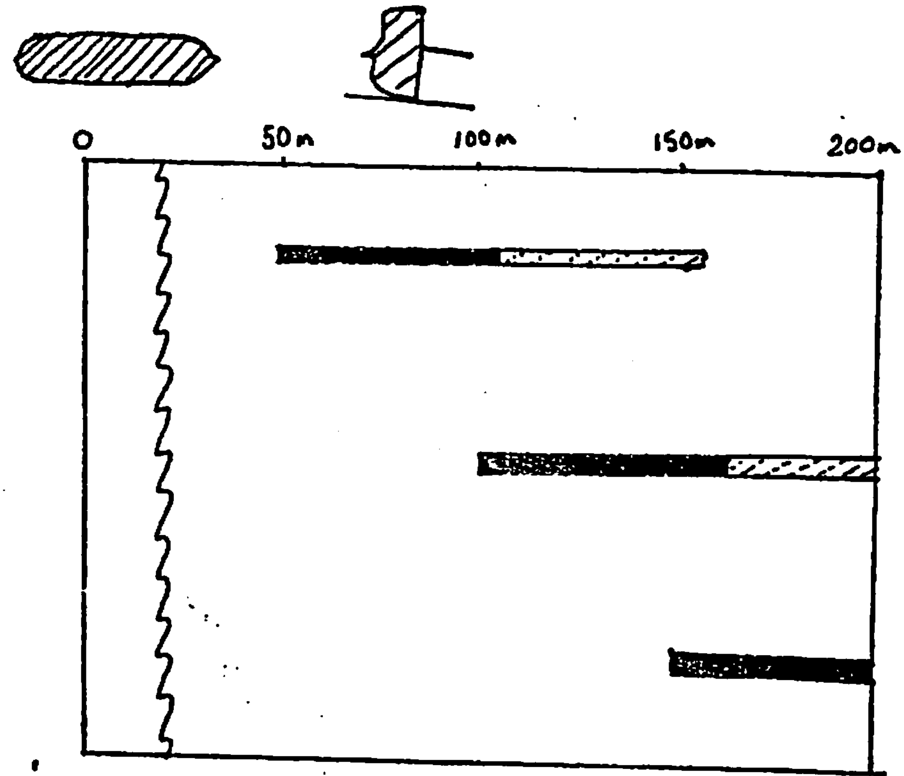
W_o = 60.5 m

L_o = 3 m



SONARGRAPH INTERPRETATION

Position #4



R_s = 50 m

L_s = 41.7 m

W_o = 60.5 m

L_o = 2.1 m

R_s = 100 m

L_s = 83.5 m

W_o = 60.5 m

L_o = 2.1 m

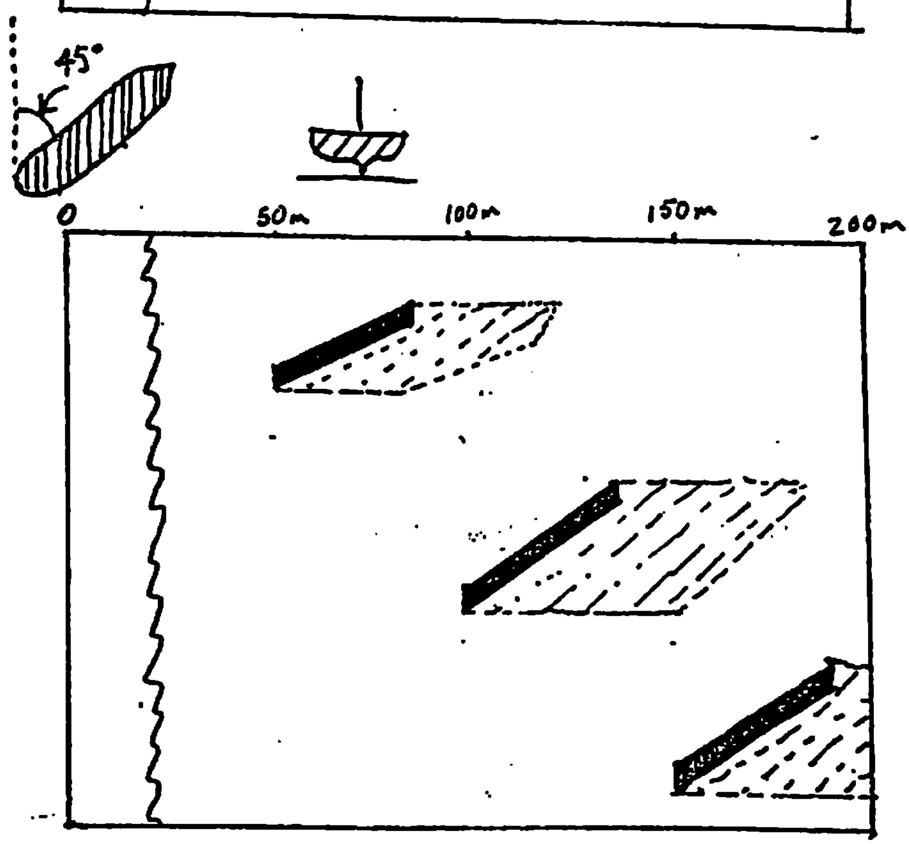
R_s = 150 m

L_s = 125.2 m

W_o = 60.5 m

L_o = 2.1 m

Position #5



R_s = 50 m

L_s = 23 m

W_o = 42.8 m

L_o = 14.3 m

R_s = 100 m

L_s = 46 m

W_o = 42.8 m

L_o = 14.3 m

R_s = 150 m

L_s = 69 m

W_o = 42.8 m

L_o = 14.3 m

SONABGRAPH INTERPRETATION

OBSERVATIONS AND COMMENTS

1. These pictures are extremes only (except #5)--anything in between is possible.
2. Distance of object from fish affects length of shadow.
3. Height of object above ground affects length of shadow and width of outline.
4. Length of object affects length of outline.
5. Speed of ship affects length of outline.
6. In all cases, the ship was assumed to be lying flat on the ground and not covered by the ground.
7. These pictures do not take various ground contours into account.

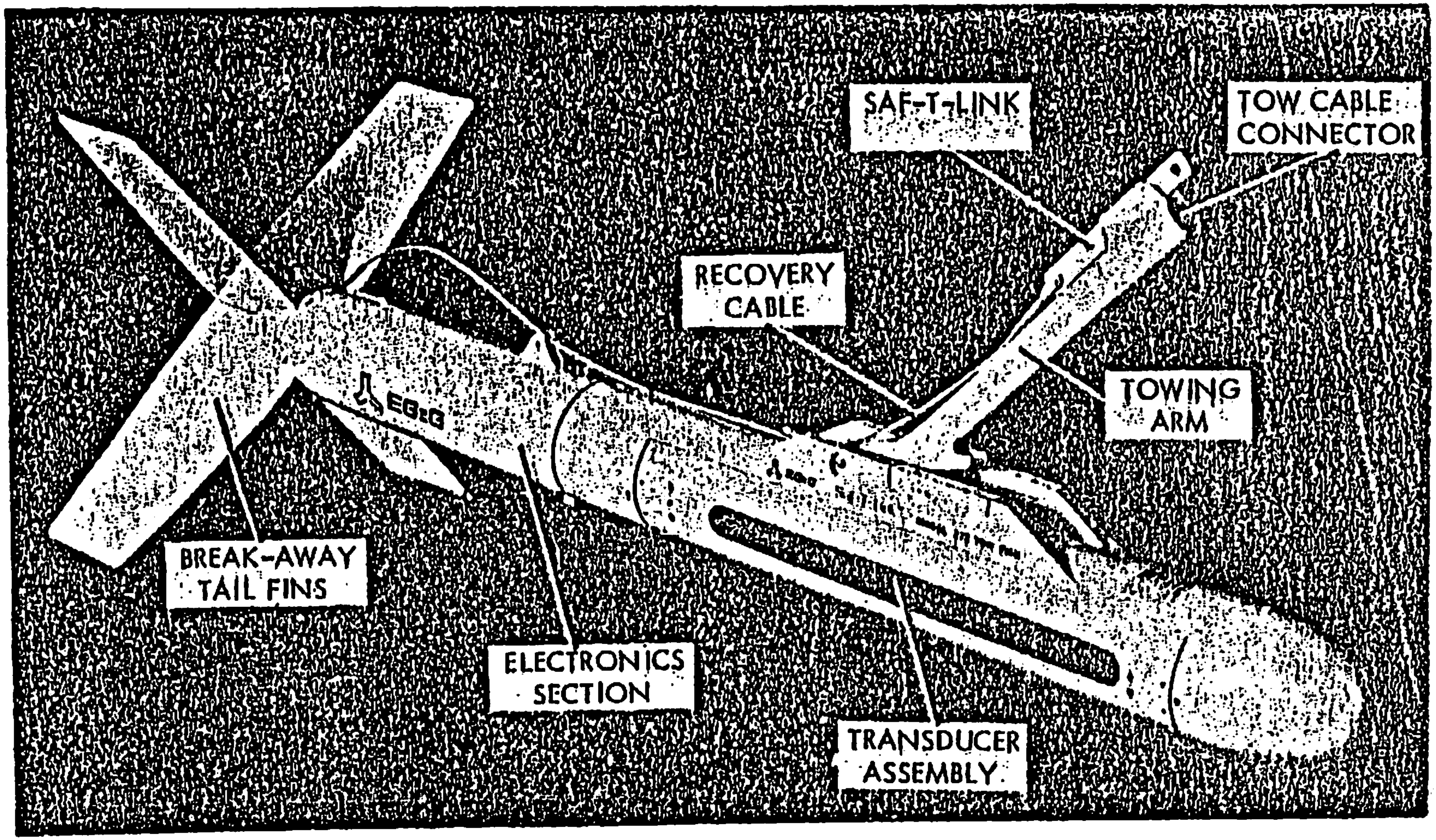


Figure SSS2. Model 272 Recoverable Tow Fish

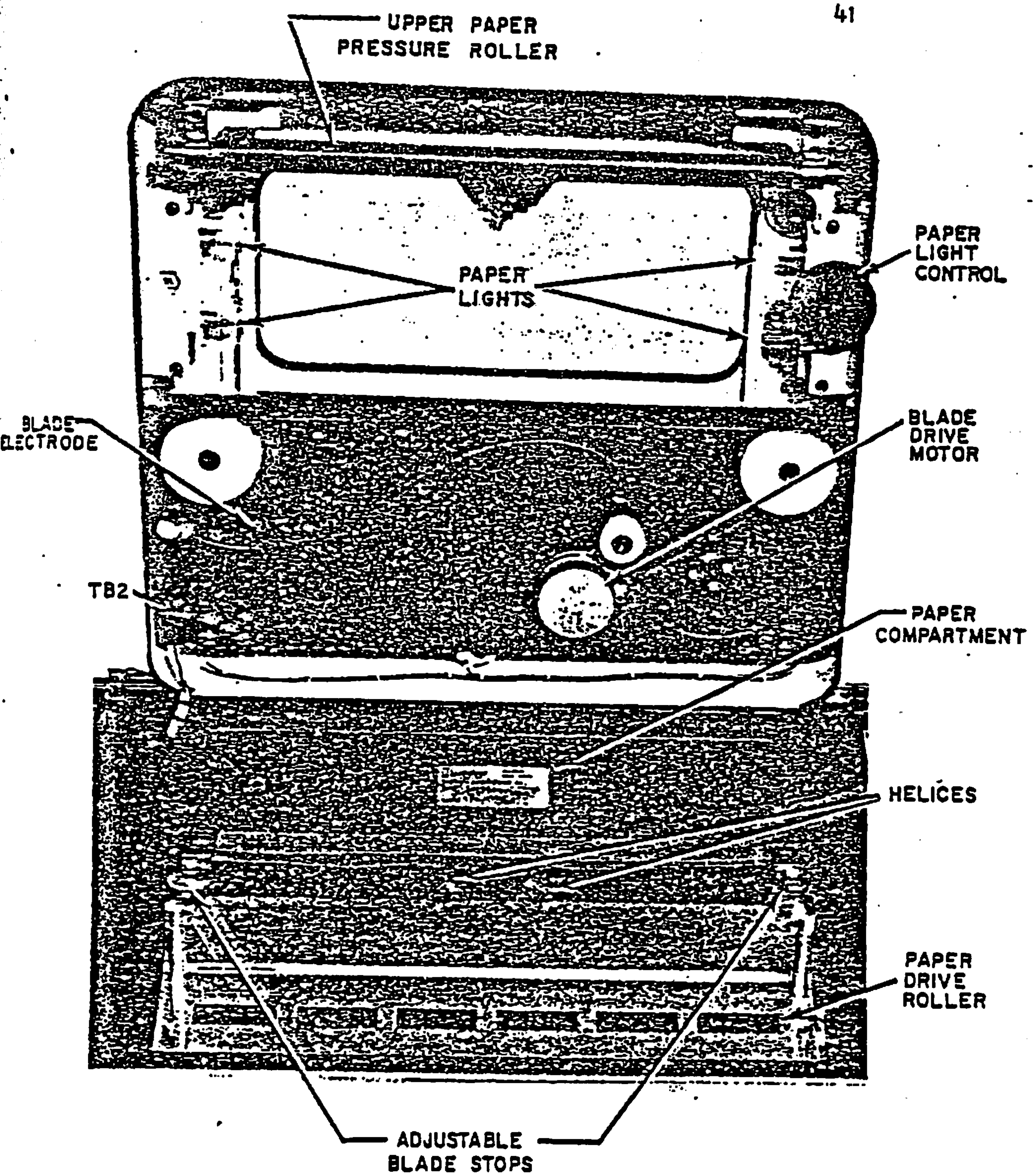


Figure SSS3. Model 259-3 Recorder,
(Top Cover Raised)

3. ANALYSIS OF THE TRACE

In order to interpret the various sonograph appearances correctly one must be aware of the factors that can cause changes in the tone or intensity of the recording paper. The darkness of the paper is influenced by two main sources: 1) the electrical source, controlled by adjusting the general and/or time varied gain; and 2) incoming signals. The incoming signals can be classified into two types. One type is caused by material properties depending on the reflectivity of the various materials on the seabed. Rock and gravel are better reflectors than sand and will therefore record darker; sand in turn is a better reflector than mud. As the grain size decreases, the acoustic reflectivity increases. The other type of incoming signal is caused by topographic features. Slopes facing the transducers are better reflectors than surfaces lying oblique to the sound beam and will consequently plot darker.

Sonographs do not normally represent isometric maps of the seabed, therefore various distorting factors have to be considered when trying to interpret images on the graph. An obvious distortion will occur parallel to the line of travel due to variable ship speeds which result in a compression of all sonographs in this direction (the faster the ship's speed, the more compressed the graph will be). Another aspect connected with the compressional effect is the distortion of all linear displays. A true angle of 45° off the line of travel at 2 knots, for example, reads in fact 63° at 5 knots and 74° at 9 knots. The height of the fish above the seabed causes a lateral distortion perpendicular to the line of travel. Range distance and true distance coincide only on a line horizontally abeam of the fish. Since the fish has to be towed a certain distance above the seabed, a certain amount of the recording paper is lost to the depth profile which plots at its respective range distance. The true distance therefore has to be fitted into the remaining part of the paper. The higher the fish is towed above the seabed, the more paper is lost for actual recording, and the smaller the perpendicular distance covered by each sweep of the fish. Furthermore, due to the oblique quality of the sonar beam, equal true distance intervals will not follow a linear scale. The short-range intervals are compressed and the long-range intervals are slightly stretched. Consequent to the various distortions, an object on the seabed (or the seabed itself) will not necessarily appear on the sonograph shaped as it is in true life.

Using distortion corrections and calculations from the sonar booklets provided to the team by Dr. Edgerton, and assuming a ship's speed of 6 knots and selected beam range of 200 meters, the team attempted to approximate the size of the BEAR's image on the sonograph. The results can be seen in Appendix SSSI.

At the end of the first week of the summer program, the team took the recorder, 50 meter cable, and fish for a trial run in Fisher's Island Sound on one of the Academy's T-boats. There the team searched for and found a car and an airplane, both previously sunk to test the sonar. The fish was towed only 5 feet below the

the surface of the water, due to the shallowness of the Sound (20-50 feet). Because of the small search area, the range scale could be set on 100 meters, 50 meters once the object was located. While this did help the team become accustomed to working with the sonar, it gave a false sense of sonograph interpretation since a larger range scale (200-250 meters) would be used for the actual search and the fish would be much farther away from the bottom. The T-boat made several passes over the airplane from different angles, and the team discovered how different an object can look just by passing over it in a different way. Sometimes the image was very sharp and other times barely distinguishable. This served as an example and a warning for the actual search.

The next time the sonar was used was aboard the USCGC CONIFER enroute to the search area. The team attached the deep tow cable, which seemed to be working well, but were unable to get a sonograph of the bottom due to the depth being greater than one thousand feet. All of the equipment seemed to work fine when it was originally tested, but when it was set up for the actual search there were some problems at first. The problems, which were eventually corrected, included: a faulty triggering wire in the long cable, water trapped in the fish-to-cable connection, and maladjustment in the recorder.

When the equipment was finally working and ready for the search, the recorder was set as would be best suited for the type of search the team was conducting. The sonar system used provides the operator with two separate recording modes of operation, survey and search, the choice of which is determined by the primary mission objective. The search mode produces records which highlight irregular objects and sharply defined bottom anomalies. Since background information is de-emphasized in this mode, small objects which might otherwise be obscured become more readily identifiable. The survey mode places record emphasis on the more subtle variations and features of the ocean floor itself. Although, like the search mode, it detects and displays anomalous objects, they are recorded without highlighting, in their normal background environment. Although less dramatic in appearance, the records produced by the survey mode provide extremely high definition. Information content is suitable for detailed record interpretation, such as identification of sediment types and shadoes of large objects. Considering the size of the BEAR, the team chose the survey mode, figuring that the shadow would be as helpful for identification as the image itself.

The recorder has six range scales which are switch selectable from the front panel. Range scales are as follows: 50,100, 125, 200, 250, and 500 meters per channel, giving total coverage for both channels from 100 to 1000 meters. The range setting to be used depends on the nature of the mission. A larger range scale will cover more are, but the image of the object will be smaller and more distorted on the sonograph. The team had originally chosen the 200 meter range, however, due to the fish height above the bottom being greater than anticipated, finally settled for 250 meters (which actually gave 300 meters on Dr. Edgerton's recorder due to his use of an AC power source). With a range scale smaller than 250 meters it would have taken much longer to cover the search area, greater than 250 would have made the ship much harder to detect. For a search much deeper than 50 fathoms, any scale lower than 500 meters would have put the ocean bottom off the sonograph (given the maximum length of cable available at the time).

There are three paper speeds of 100, 150, or 200 lines/inch. This is an internal adjustment not readily available on the front panel by design to eliminate the hazard of an operator indiscriminately changing paper speed in the middle of an operation and invalidating any meaningful measurement on the record in the direction of the ship's travel. The recorder is factory set at 150 lines/inch, which was the speed of the paper for the BEAR search. However, the team did not use this information, but instead measured distance in the direction of the ship by measuring a minute interval with event marks. All that is then necessary for distance measurement is the ship's speed.

The tow fish transducer assemblies are mounted such that by removing ten screws, the port and starboard assemblies can be pulled out to exchange one assembly for the other to alter the vertical beam depression angle from the horizontal from 10° to 20°. By changing the electrical hook-up, the vertical beam width can be changed from 20°-50°. For surveying in shallow water (up to about 100 feet) where the fish must be close to both surface and bottom, a 10° beam depression with a 20° vertical beam width is normally used to obtain good coverage at both near and far range. For surveying in deep water (generally 200 feet or more), a 20° beam depression and a 50^{o} vertical beam angle provide better near and far range coverage, which is what the team used for this search.

The general gain control intensifies all incoming signals evenly across the paper. It is best to keep the gain at an intermediate shade of darkness, such that both images and shadows would be readily apparent on the sonograph.

In order to keep an accurate account of the sonograph, an automatic five-minute event mark, supplied by Dr. Edgerton, was used and the time was marked on the graph with a felt marker. The event mark can be used manually at any desired time interval, however, the automatic marker is more accurate. Any necessary markings on the graph should be done with a felt tip marker, as this will not tear the paper. Marks should not be allowed to cover any portion of the graph which displays the bottom.

Optimum towing height off the bottom depends on bottom conditions and the goals of the mission. The tow fish is usually towed at a distance above the sea floor equal to 10-20 percent of the range scale in use, however, the actual working depth of the fish is controlled by the length of the cable deployed, vessel towing speed, and vessel course (sharp turns cause the fish to go deeper). With the entire length of the longest cable deployed (150 meters), the fish was still 80 meters above the bottom for most of the search, whereas 25-50 meters would have been better for the range selection used by the team. The depresser, which was not used, would have added about ten meters of depth, but would have developed 450 lbs of force, which could pull someone overboard.

All things considered, the side scan sonar was an excellent choice of instruments for this search. However, when using the sonar, its capabilities and limitations must always be kept in mind.

C. OPTIONAL EQUIPMENT

1. PRECISION FATHOMETER

In order to get an accurate account of the ocean depth, the team took along the Raytheon DE-719-RTT portable, precision, survey-type fathometer depth recorder, which is a complete echo depth sounder designed to provide a detailed permanent recording of underwater topography in depths up to 410 feet. Ease of set-up and operation, plus the extreme accuracy and low power consumption makes this an ideal instrument for underwater surveying. It was hoped that in addition to giving an accurate depth recording, the fathometer would show if the ship traveled directly over the BEAR. However, the team did not make much use of this instrument since the search ship had its own fathometer, which was connected to the keel thereby eliminating bias due to roll.

2. V/W TELEVISION

The underwater television/still camera combination consists of a steel cage with an underwater low light television camera, an incandescent light, a still camera and a strobe light. The whole assembly is lowered by a one-half inch nylon line. The television picture and the signals to turn on the light, fire the strobe and release the camera shutter are sent via a water proof cable. The television camera output is then hooked up to a monitor which can also be hooked up to a video tape recorder as well.

The purpose of the underwater television camera is to provide eyes for the surface observers. The camera can be lowered down on a target and one can see what is really there. The still camera and strobe give a permanent record of what is seen on the television monitor.

3. PRECISION SONAR

The radial arm sonar consists of a sonar transducer mounted on a pole that rotates and has a magnetic compass on it to indicate the direction the pole is pointing. This sonar is used to pinpoint the exact location of the contact so that the camera can be sent down. This sonar can easily be used in a small boat and has the advantage of being highly mobile. With this sonar the small boat can be driven directly over the underwater contact.

D. BUOY SYSTEM

The intended purpose of the buoy system used in the underwater search MAP is to place a visible, stationary mark on the ocean surface to identify the location of an underwater contact found by the side scan sonar unit. These buoys had to be easy to deploy and highly visible while being as simple in construction as possible. These buoys were intended to stay on station for a period of not less than seven days.

1. DESIGN

The design of the buoy system was derived from previously produced models and suggestions by instructors. Parts of the buoy system had been purchased before the design process was complete, and a major task was integrating the materials on hand with the design of the buoy.

The basic buoy system consists of the following main components: a buoy with a counter weight, radar reflector and retriever float, nylon line, a small styrofoam float, a short scope of chain, and a concrete sinker.

The main part of the buoy is a polymer coated core of styrofoam with a tubular metal shaft running the length of the major axis of the buoy. The foam core consists of two hemispheres connected by a cylinder of styrofoam. The polymer coating is tough, abrasion resistant and international orange in color. This combination yields a sturdy, highly visible watertight structure giving the buoy durability and strength.

The buoy was the first part of the system purchased, and the rest of the design followed this. The radar reflector is used to increase the visibility of the buoy, both visually and on radar. The counter weight functions to keep the buoy as vertical in the water as possible, by counteracting the wind moments on the buoy and radar reflector, as well as the force exerted on the buoy by the line and sinker. The retriever float is used to bring the buoy aboard when it is retrieved.

The radar reflector and the counter weight are both mounted away from the center of gravity of the buoy on a ten foot section of electrical conduit running through the buoy along its major axis, increasing the visibility of the radar reflector and giving the counter weight a greater righting moment.

Nylon line was used due to its high strength to weight ratio which allows a small diameter line to have a high breaking strength. This combination yields a strong line with reduced drag.

The small styrofoam float is used to add buoyancy to the line and prevent tangling upon bottom features.

The short scope of chain is used to take the strain of the sinker as it is ready to be dropped. The sinker is placed over the side with the chain in a pelican hook.

The sinker is used to keep the buoy on station at all times.

2. CONSTRUCTION

The buoy assembly consists of the purchased buoy, a ten foot section of electrical conduit, one or two radar reflectors, one 1/2" x 4" eyebolt, two 3/8" x 4" bolts and nuts and a small cinder block. The radar reflector is tied to the conduit through two holes drilled in the conduit. The conduit is attached to the buoy by a 3/8" x 4' bolt at the top of the buoy's tubular shaft. The buoy is attached to the conduit at a point 23 inches from its base, with a 1/2" x 4" eyebolt through the conduit and a tubular shaft. The counter weight is attached to the conduit by a 3/8" x 4" bolt and a loop of nylon line around the bolt. The other end of this line is tied to the cinder block weight.

The nylon line, a 400' length of 1/2 inch or 1/4 inch line, has a snap hook and swivel on the end that attaches to the eye-bolt of the buoy, and a thimble spliced into the sinker end. Smaller lengths of line (100' + 50' lengths) with snap hooks in one end and thimbles in the other end can be clipped in easily to lengthen the scope of line. The base length of 400' was determined on the basis of a 300 foot working kepth with a slow, approximately 0.2 knot, current profile. The nylon line is attached to the chain with a screw pin shackle. The chain, approximately eight feet in length, is attached to the concrete block with a screw pin shackle. The concrete sinkers are various shapes and weigh between 300 and 600 lbs. There is a metal hook imbedded in the concrete to attach the chain to.

The small styrofoam float is attached to the line approximately 200 feet from the fottom by means of a five foot length of nylon line tied through the float and the braid of the buoy line. To aid in recovery a 2' x 4' x 6' block of wood painted bright orange with an eighteen foot length of 1/2 inch nylon line attached to the block and the eyebolt on the buoy.

3. ACTUAL PERFORMANCE

The actual performance of this buoy system was very good. The deployment of the buoy was simple and fast. The deployment of the buoy was simple and fast. The deployment procedure is as follows: Preliminary steps: hang the sinker over the side of the ship; put the sinker chain in a quick release pelican hook to take up the strain; hook a length of line to the chain (it helps to have the line faked out in a small cardboard or wooden box so that it will run free, and it is not on the deck to get tangled); hook the other end of the line to the buoy; have the buoy all rigged out with the radar reflector, counter weight and retriever float. Final steps: when the command to let go a buoy is given, trip the quick release pelican hook and watch the line play out. When most of the line has gone out, pick the completed buoy up, and lower it into the water. Deployment is complete. The retriever float is used so that a line attached to the buoy can be easily picked up by the ship to speed recovery operations.

It is possible to have two or more buoys ready to be deployed at a moment's notice. The one buoy that was deployed functioned quite well. It rode in the water in a near vertical position and was visible on the ship's radar most of the time. This was important as the predominant weather condition during the search was fog. According to the LORAN-C, the buoy remained on station the six day duration of the trip.

4. A COMPUTER MODEL OF BUOY SYSTEM

a. Introduction

This simplified computer model was developed to evaluate (theoretically) the buoy-mooring system for the marker buoys to be used on the "Find the BEAR" project. The analysis is an interactive converging solution of the interdependent vertical and horizontal forces on the buoy.

b. Methodology

The analysis initially assumes a draft of the hull and from this computes the buoy's horizontal drag. The cable drag is computed and added to the buoy drag to give the cumulative horizontal component of tension at the sinker. The vertical component of tension at the sinker is resolved from the horizontal component of tension and the scope (for a straight (taut) mooring line approximation). This vertical component is summed with the cable weight and the buoy weight to compute the buoyant force required to counteract the cumulative downward forces. Finally, a new draft is computed from the buoyant force required and is reinserted into the assumed initial draft for subsequent iterations until convergence is attained. By this analysis method, the draft, horizontal and vertical components of mooring line tension, and the resultant mooring line tension can be calculated as functions of the buoy size and weight, water depth, mooring line size and weight, mooring scope, and current velocity.

c. Assumptions

In order to simplify calculations, these assumptions were made:

1. That the effect of wind is negligible.

2. A uniform velocity current profile exists.

3. That the sinker is fixed to the bottom.

4. That the analysis is limited to a two dimensional analysis of coplanar forces.

5. That the buoy maintains an upright orientation under all conditions.

6. That the buoy remains in a vertical orientation.

7. Wave making resistance is neglected.

8. That the effect of waves is negligible.

9. The negative lift of the cable is negligible.

d. Approximations

The following approximations were used in the model:

1. The drag on the cable is considered only in the direction of current flow and not along the cable.

2. The coefficient of drag for the cable is 1.2 or 3.0 for a strumming cable.

3. The coefficient of drag for the buoy is 2.0.

4. The coefficient of lift for the buoy is 0.0.

5. The center of gravity of the mooring cable is 0.75 the horizontal excursion.

e. Analysis

The analysis of the system shown in Figure 1 is based on the following fundamentals:

1. The sum of the vertical forces on the system must be zero.

2. The sum of the horizontal forces on the system must be zero.

3. The relationship between the vertical and horizontal components of mooring cable tension is dependent on the mooring configuration.

The vertical forces acting within the system are briefly described:

Buoy weight (Bwt): independent variable

Buoy buoyancy (Bync): dependent variable

Buoyancy is equal to the weight of the water displaced by the buoy which is a function of buoy draft (Dft).

Cable weight (Cwt): independent variable

Sinker vertical force (Tvs): The vertical component of mooring cable tension at the sinker.

Since the sum of all vertical forces within the system must be zero, the following equation can be developed from Figure 1:

$$T_{vs} = B_{ync} - C_{wt} - B_{wt} \qquad (1)$$

The horizontal forces acting within the system are briefly described below:

FIGURE 1

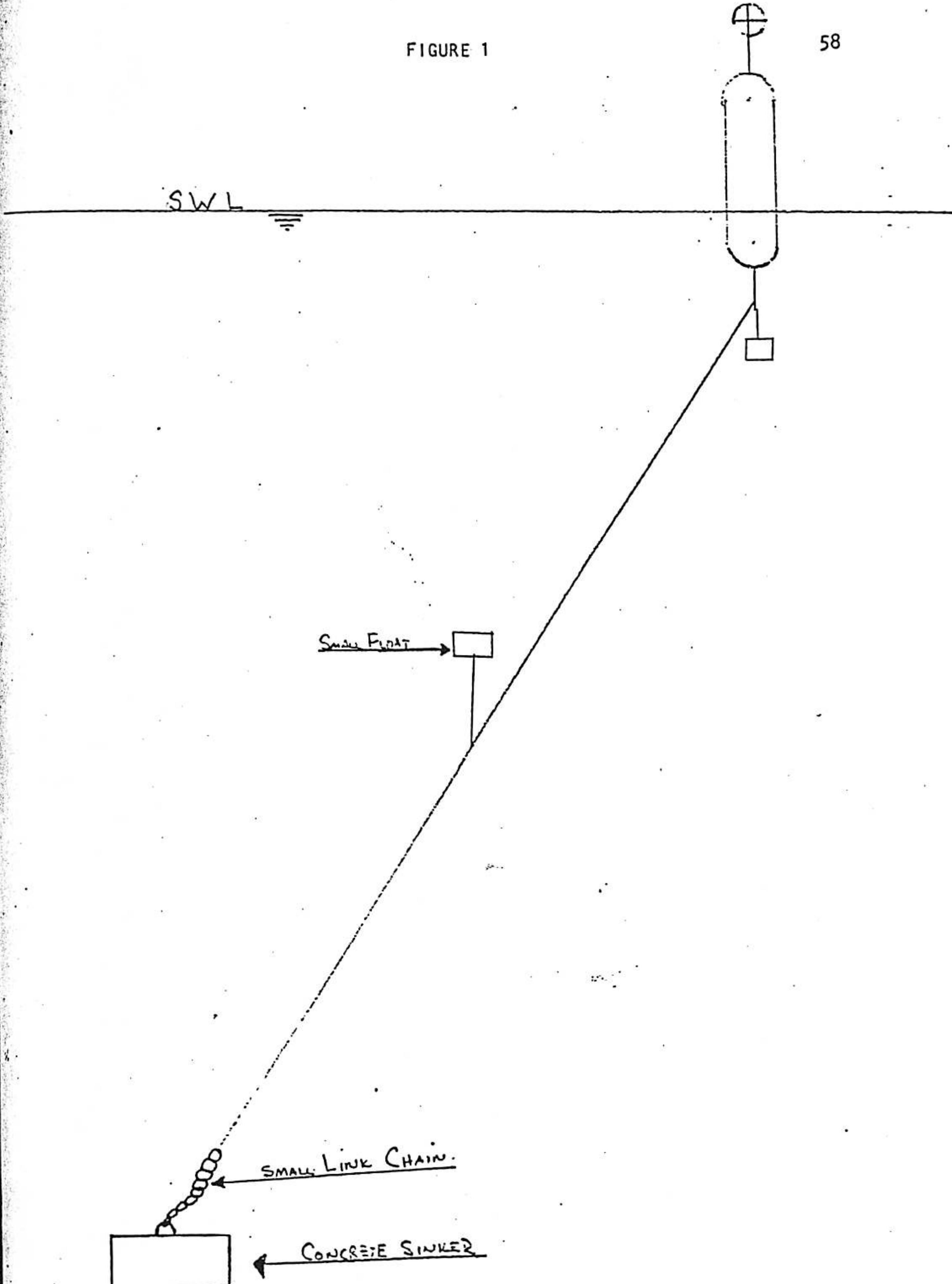
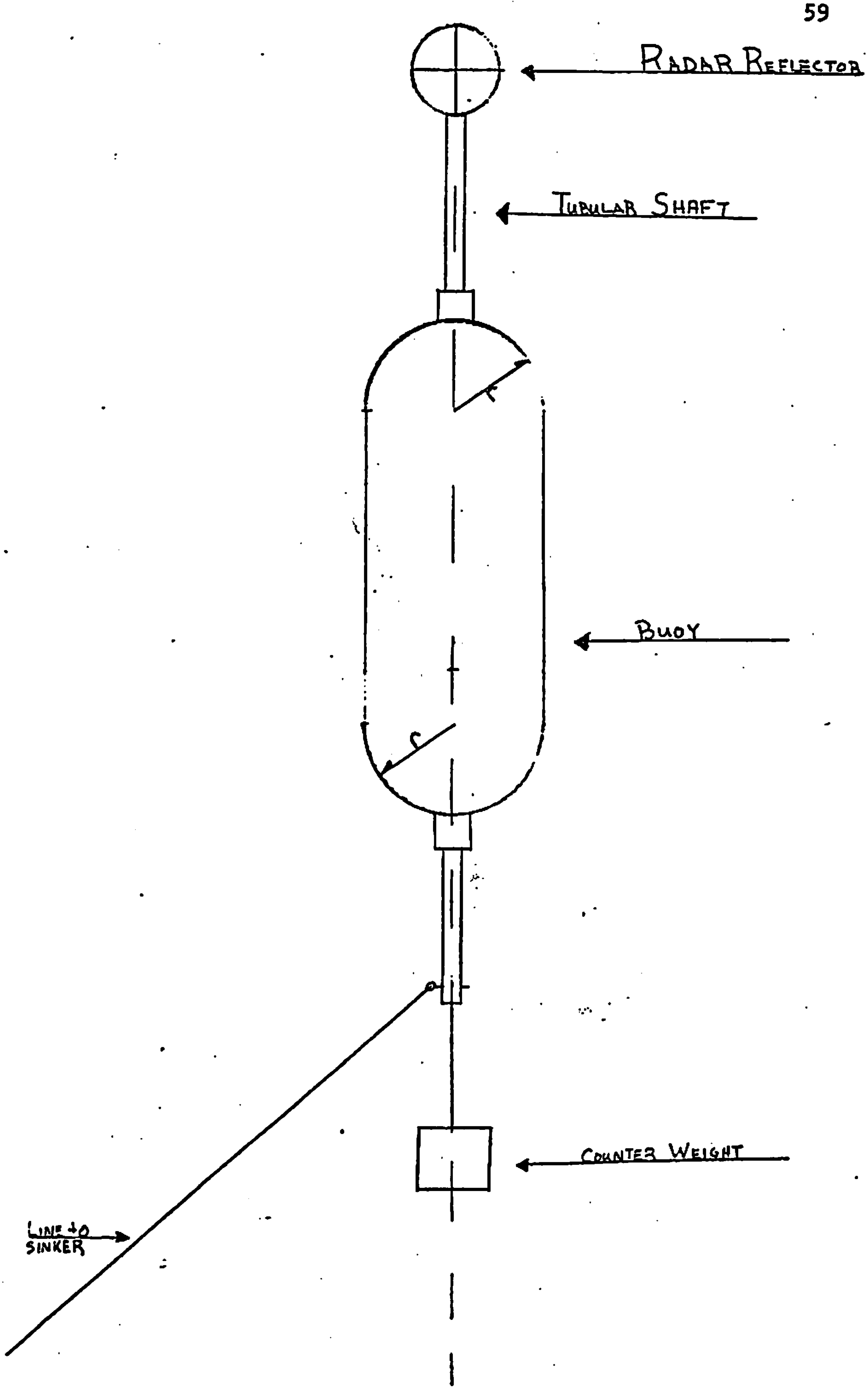


FIGURE 1 (cont'd)



Buoy drag (Db): dependent variable

Buoy drag is determined from the basic drag equation:

$$D_b = \frac{1}{2} \rho C_{db} P_{ba} V_{el}^2 \quad (2)$$

where:

ρ = density of water

V_{el} = current velocity

P_{ba} = projected area of the below water portion of the buoy and is dependent on buoy draft (dft).

C_{db} = coefficient of buoy drag

Cable Drag: dependent variable

Cable drag is also determined from the basic drag equation and is dependent on three of the input parameters (Current velocity (VEL)), water depth (Dpth) and cable diameter (Dia).

$$D_c = \frac{1}{2} \rho C_{db} P_{ca} V_{el}^2 \quad (3)$$

where:

P_{ca} = projected are of the cable which is the product of the water depth and cable diameter.

C_{dc} = coefficient of cable drag

Sinker horizontal force (Ths): The horizontal component of mooring cable tension at the sinker.

$$THS = D_b + D_c \quad (4)$$

The relationship between the vertical and horizontal components of mooring cable tension is dependent on the mooring configuration.

$$\Sigma M_{sinker} = 0 \approx (X\ T_{vb}) - (D_{pth} - D_b) - D_{pth}\ D_c/2) - (\tfrac{3}{4} \times C_{wt}) \quad (5)$$

where:

$$T_{vb} = B_{ync} - B_{wt} \tag{6}$$

From Equations (1), (4), and (5) the interdependency of buoyancy with respect to buoy draft, and buoy drag with respect to buoy draft can be determined. The buoy draft is a function of the buoyancy required and effects the buoy drag which in turn effects the buoyancy required. For any steady state condition there exists a unique draft that will satisfy the equations.

The converging solution method was selected for determining the unique draft for each input condition. In this solution (the flow chart is shown in Figure 2) a draft is assumed and a sequence of the above equations is used to determine a new estimate of the draft which is closer to the unique solution. After several iterations (about 10 depending on the accuracy of the first assumed value) the drafts do not change, hence, the solution of draft is reached, and the corresponding mooring tension components can be computed.

FIGURE 2

Flow Chart of Buoy-Mooring System Analysis

Assumed Draft
(Dft)

Input
Conditions

Calc. Pba
from geometry and Dft

Calc. Db
$Db = Rho\ Cdb\ Pba\ Vel^2/2$

Calc. Dc
$Dc = Rho\ Cdc\ Pca\ Vel^2/2$

Calc. Ths
$Ths = Dc + Db$

Calc. Tvb
(Equation 5)

Calc. Bync
$Bync = Tvb + Bwt$

Calc. New Dft from
geometry and Bync

No

Converge

Yes

Dft Ths Tvb
Tvs Thb
Tts Ttb

TABLE I

LIST OF VARIABLES

*Rho	Density of water
*Bch	Buoy cylinderical section height
*Bwt	Buoy weight
Bync	Buoyancy of the buoy
*Cdb	Coefficient of buoy drag
*Cdc	Coefficient of cable drag
*Cl	Cable length
Cwt	Cable weight
Db	Drag of the buoy
Dc	Drag of the cable
Dft	Draft of the hull
*Dia	Cable diameter
*Dpth	Water depth
g	Acceleration of gravity
Pba	Projected area of the below waterline portion of the buoy hull
Pca	Projected area of the cable
Fb	Buoy freeboard
*Rds	Radius of spherical section
Scp	Scope of mooring
*Sge	Specific gravity of cable
Ths	Horizontal component of tension at the buoy
Thb	Horizontal component of tension at the buoy
Ttb	Tension at the buoy
Tts	Tension at the sinker
Tvb	Vertical component of tension at the buoy
Tvs	Vertical component of tension at the sinker
*Vel	Current velocity
V_b	Volume of water displaced by buoy
V_c	Volume of water displaced by cable
X	Horizontal excursion

*Input

APPENDIX I

CALCULATION OF BUOY BUOYANCY BUOY SHAPE

Spherical Section
with 1 base

Cylinder

Spherical section
with 1 base

Buoy Buoyancy:

$$\text{Bync} = \rho g V_b$$

Case:

I V_b = volume of spherical section
if $\text{Dft} < \text{Rds}$

II V_b = volume of hemisphere + volume of a cylinder
if $\text{Rds} < \text{Dft} < \text{Rds} + \text{Bch}$

III V_b = volume of cylinder + volume of sphere -
volume of spherical section (above surface)
if $\text{Rds} + \text{Bch} < \text{Dft} < 2\ \text{Rds} + \text{Bch}$

IV V_b = volume of cylinder + volume of sphere
if $\text{Dft} > 2\ \text{Rds} + \text{Bch}$
i.e. buoy fully submerged

APPENDIX 1-Cont'd

Case I: if $Dft < Rds$

$$V_b = \pi D_{ft}^2 (Rds - \frac{Dft}{3})$$

Ref: Eshbach pg. 262
third edition

Case II: if $Rds \leq Dft \leq Rds + Bch$

$$V_b = \frac{1}{2} \cdot \frac{4}{3} \pi Rds^3 + \pi Rds^2 (Dft - Rds)$$

Case III: if $RDS + Bch < Dft < 2\ Rds + Bch$

$$V_b = \frac{4}{3} \pi Rds^3 + \pi Rds^2\ Bch - \pi F_b^2 (Rds - \frac{Fb}{3})$$

where:

$$Fb = 2\ Rds + Bch - Dft$$

Case IV: if $Dft \geq 2\ Rds + Bch$

$$V_b = \frac{4}{3} \pi Rds^3 + \pi Rds^2\ Bch$$

APPENDIX II

CABLE WEIGHT

Cable weight = Cwt = Sgc g V_c

$$V_c = \frac{\pi \, Dia^2}{4} C_\ell$$

$$Cwt = \frac{Sgc \; \rho \, g \; C_\ell \;\; \pi \, Dia^2}{4}$$

APPENDIX III

BUOY DRAG

Buoy drag = $D_b = \frac{1}{2} \rho \, C_{db} \, P_{ba} \, Vel^2$

P_{ba} must be calculated for each of the four cases in Appendix I.

Case I. $A = \frac{r}{2} (\theta - \sin \theta)$

Ref: Eshbach pg. 258.

θ_r in radians θ^o in degrees

$$\frac{\theta}{2} = \text{arc cos } (Rds - Dft)(Rds)$$

$$\theta_r = \frac{\pi}{180} \theta^o = \frac{2\pi \text{ arc cos } (Rds - Dft)Rds}{180}$$

$$P_{ba} = \frac{Rds^2}{2} \left[\frac{2\pi}{180} \text{ arc cos } ((Rds - Dft)/Rds) - \sin (2 \text{ arc cos } ((Rds - Dft)/Rds)\right]$$

Case II.

$$P_{ba} = \frac{1}{2} \pi \, Rds^2 + 2 \, Rds \, (Dft - Rds)$$

Case III.

$$P_{ba} = \pi \, Rds^2 + 2 \, Rds \, Bch - \frac{Rds}{2} \left(\frac{2}{180} \text{ arc cos } ((Rds - F_b)/Rds) - \sin (2 \text{ arc cos } ((Rds - F_b)/Rds))\right)$$

Case IV.

$P_{ba} = \pi Rds^2 + 2\ Rds\ Bch$

APPENDIX IV

CABLE DRAG

$D_c = \frac{1}{2}\ \rho\, C_{dc}\ P_{ca}\ Vel^2$

$P_{ca} = D_{pth}\ ,\ Dia$

$D_c = \frac{1}{2}\ \rho\ C_{dc}\ D_{pth}\ Dia\ Vel^2$

III. EQUIPMENT DEPLOYMENT

A. SEARCH PATTERNS

1. SEARCH AREA DETERMINATION

The first step in an underwater search is to determine a search area from all the available information. The last known position is one of the most useful pieces of information available. There were two last reported positions of the BEAR, one given by the towing vessel, the IRVING BIRCH, of 41°52'N, 65°11'W, and the other was based on the flight of a Coast Guard aircraft, 42°25'N, 65°35'W. The two positions did not concur, but it was assumed that more faith could be placed in the aircraft's position. All other information was gathered under this assumption. The captain of the IRVING BIRCH reported the BEAR's lights going out at 2000 that night, but due to a misunderstanding, it was assumed that the lights went out at 2200 which added an extra two hours of leeway time to the computations. It was assumed that there was ten hours of drift time and all the information was derived using this assumption. Two questions came up during the search which merit investigation if this search is repeated. Firstly, what was the rate of sinking and what affects did currents have, and secondly, was the IRVING BIRCH leaving the locale of the BEAR, opening the possibility that the BEAR's lights disappeared below the horizon and not below the surface of the water. These questions must be answered.

Assuming that the position of 42°25'N, 65°35'W was correct, a search area was outlined. The method used in setting up the search area was twofold. First to be examined were the currents and wind effects to obtain a predicted location of the BEAR. Second, a Naval chart was used to see what wrecks had been charted in the area. The most promising wreck was taken as the center of the search area and, after applying compensations for error, a creeping line search through this location was conducted.

The first item of interest that was researched was the currents of the search area. Four types of currents were studied for the construction of a search area. They are tidal, wind driven, Stokes drift, and ocean currents. The second item that was studied was the leeway, the effect of the wind on the drift of the vessel.

The wind driven currents were determined by a computer program developed by Ensign Bruce Viekman, USCG, as an extension to a program originally developed by Pollard and Millard in 1972. It requires as entering arguments the wind velocity and direction for four days prior to the requested time, and the temperature gradient from the surface to the bottom. The wind velocity and direction were obtained from microfilm provided by the National Weather Service, which gave the surface charts for the months of January through March of 1963. The wind was estimated for the location of interest from the closest reporting station or ship for the days in question. The temperature gradient was found in Government Publication #700, Atlas of the North Atlantic Ocean.

The computer program outputs for each hour of drift time, the north and east components of the wind driven currents along with their resultants for each five meters of depth. The hourly displacements were summed for the time the BEAR was adrift (see Figure 3-A-1). The displacement values given in the putput were cumulative.

The velocity of the Stokes drift current is approximately one to two per cent that of the wind and in the same direction. The speed can be approximated by the wind driven current. This current deteriorates with depth. It is produced by the flowing of the waves; the larger the waves, the larger the current. The speed of the Stokes current was approximated by the wind driven current and assumed to be in the direction of the wind, 135°T, at a speed equal to the wind driven current at the surface.

The tidal currents in the area are of the Rotary type; that is, they make a 360° circle every twelve hours and twenty-five minutes. To find these currents, the tidal current roses on chart 13009, produced by the National Ocean Survey of NOAA, were used. These current roses are designated for each hour after maximum flood current. They have a linear scale on the chart, and the maximum flood current is found for Polluck Rip Channel in the Tidal Current Tables. These are the only predictions of what the currents will be, but these were the best available information. The total drift vector was determined by summing the current velocities for the hours the BEAR was adrift.

The ocean currents were determined from drift bottle tests. These tests measure the ocean streams, bottom currents, and other

NODC SURFACE CURRENT (SHIPS DRIFT) LONG SUMMARY

10-DEGREE SQUARE 1308 1-DEGREE SQUARE 36 — MONTH 11
RESULTANT DIRECTION 135 TOTAL OBSERVATIONS 4 NORTH COMPONENT -0.1
RESULTANT SPEED 0.1 EAST COMPONENT 0.1

DISTRIBUTION OF INDIVIDUAL OBSERVATIONS

	KNOTS(CM/SEC)	N	NE	E	SE	S	SW	W	NW	SUM	PER-CENT
	CALM									0	0.0
	0.1 (5)	0	0	0	0	1	0	0	0	1	25.0
S	0.3 (15)	0	0	0	0	0	0	1	0	1	25.0
P	0.5 (26)	0	0	1	1	0	0	0	0	2	50.0
E	0.7 (36)	0	0	0	0	0	0	0	0	0	0.0
E	0.9 (46)	0	0	0	0	0	0	0	0	0	0.0
D	1.1 (57)	0	0	0	0	0	0	0	0	0	0.0
	1.3 (67)	0	0	0	0	0	0	0	0	0	0.0
C	1.5 (77)	0	0	0	0	0	0	0	0	0	0.0
L	1.7 (88)	0	0	0	0	0	0	0	0	0	0.0
A	1.9 (98)	0	0	0	0	0	0	0	0	0	0.0
S	2.5 (129)	0	0	0	0	0	0	0	0	0	0.0
S	3.0 (154)	0	0	0	0	0	0	0	0	0	0.0
	3.5 (180)	0	0	0	0	0	0	0	0	0	0.0
	4.0 (206)	0	0	0	0	0	0	0	0	0	0.0
	>4.0(>206)	0	0	0	0	0	0	0	0	0	0.0
	SUM OF OBS.	0	0	1	1	1	0	1	0		
	PERCENT OBS.	0.0	0.0	25.0	25.0	25.0	0.0	25.0	0.0		100.0
	MEAN SPEED	0.0	0.0	0.4	0.4	0.1	0.0	0.3	0.0		
	MAX. SPEED	0.0	0.0	0.4	0.4	0.1	0.0	0.3	0.0		
	STD DEVIATION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

10-DEGREE SQUARE 1308 1-DEGREE SQUARE 36 — MONTH 12
RESULTANT DIRECTION 315 TOTAL OBSERVATIONS 1 NORTH COMPONENT [illegible]
RESULTANT SPEED 0.8 EAST COMPONENT -0.6

DISTRIBUTION OF INDIVIDUAL OBSERVATIONS

	KNOTS(CM/SEC)	N	NE	E	SE	S	SW	W	NW	SUM	PER-CENT
	CALM									0	0.0
	0.1 (5)	0	0	0	0	0	0	0	0	0	0.0
S	0.3 (15)	0	0	0	0	0	0	0	0	0	0.0
P	0.5 (26)	0	0	0	0	0	0	0	0	0	0.0
E	0.7 (36)	0	0	0	0	0	0	0	0	0	0.0
E	0.9 (46)	0	0	0	0	0	0	0	1	1	100.0
D	1.1 (57)	0	0	0	0	0	0	0	0	0	0.0
	1.3 (67)	0	0	0	0	0	0	0	0	0	0.0
C	1.5 (77)	0	0	0	0	0	0	0	0	0	0.0
L	1.7 (88)	0	0	0	0	0	0	0	0	0	0.0
A	1.9 (98)	0	0	0	0	0	0	0	0	0	0.0
S	2.5 (129)	0	0	0	0	0	0	0	0	0	0.0
S	3.0 (154)	0	0	0	0	0	0	0	0	0	0.0
	3.5 (180)	0	0	0	0	0	0	0	0	0	0.0
	4.0 (206)	0	0	0	0	0	0	0	0	0	0.0
	>4.0(>206)	0	0	0	0	0	0	0	0	0	0.0
	SUM OF OBS.	0	0	0	0	0	0	0	1		
	PERCENT OBS.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0		100.0
	MEAN SPEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]		
	MAX. SPEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]		
	STD DEVIATION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

FIGURE 3-A-1

forces not already mentioned. From the data obtained, the ocean currents were to the northwest at about five miles per day. When computing the search area two arcs were drawn, one including these ocean currents.

The final factor considered was the wind's affect on the ship while it was adrift, leeway. Initially it was assumed that the BEAR would act as a sea drogue because of its draught. However, its masts provided a large sail area which resulted in leeway accounting for a great amount of drift. In order to use the drift tables in the Search and Rescue Manual, it was assumed that the tables applied to the BEAR and that the wind blew at a steady 20 Kts. for the entire time it was adrift. Research shows that a vessle may drift up to 90° to either side of the direction of the wind. The distance drifted was taken from the SAR manual, and the wind direction was towards 135° T. An area was then drawn by swinging an arc 90° to either side of the wind direction. The predicted area of the location of the BEAR was determined by summing all the displacement vestors from the different sources of information. There were two arcs drawn, one including the ocean currents, and one without.

Based on the information available, the search area was too large to cover in the time available. Additional information from Naval charts indicated two wrecks within the area in which the BEAR was assumed to be. Due to time constraints, it was decided to search these areas first.

2. PROBABILITY OF DETECTION

The purpose of this section is to discuss the probability of detection in underwater search employing side scan sonar, and specifically how it applies to the search for the BEAR. Probability of detection is a mathematical expression of the chance one has of finding an object given it is in the search area.

The National Search and Rescue Manual, CG 308, delineates a method of determining the probability of detection, but it is not complete and may have to be modified, as will be explained later.

Three items one must consider when determining the probability of detection are: the track spacing of the vessel conducting the search, the sweep width of the vessel's sensors, and the number of times the vessel has conducted the search in the exact same area.

The track spacing is the distance between adjacent search tracks. It is a variable that can be decreased to produce a better probability of detection.

The sweep width is a measure of the detection capabilities, in yards, of the searching vessel. Unfortunately, the SAR manual has no sweep widths for underwater search computed. It was determined that a good approximation of the sweep width for a vessel employing side scan sonar equipment would equal twice the effective range of one transducer. This is probably true in most instances of recorder use in searching for a vessel as large as the BEAR, but as lateral and/or compressional distortions (see section II.B. on Side Scan Sonar) increase it would be safe to say that this is no longer true.

While it is intuitively obvious that as the size of the object increases the P.O.D. increases and as the distortions increase the P.O.D. decreases, it is necessary to determine exactly how these and other items affect the sweep width. A sweep width table should be constructed for underwater/side scan sonar search vessels to be used in conjunction with CG-308. The SAR manual states that electronic searches are very efficient, with a large sweep width. Relatively large track spacings can be employed and still yield a high probability of detection over large geographic areas in a short period of time.

The probability of detection tables found in the SAR manual may be used irregardless of the type of search, given that a value for the sweep width can be determined.

By dividing the sweep width by the track spacing, a dimensionless number known as the coverage factor is obtained. By entering the coverage factor and the number of searches done in the exact same area and pattern into figure 8-65 of the SAR manual the probability of detection for that search area is obtained.

Six different areas were explored during the search for the <u>BEAR</u>. In all but the last search area the sweep width was calculated as previously described, the total true distance recorded on both sides of the transducer fish. In the last case it was decided to use the value of only one side due to the height of the fish and the unfortunate sloppiness of the search track followed by the ship. This number, however, was somewhat arbitrary and may in fact be wrong, but it will have to suffice due to the lack of knowledge on the subject.

The effective range of one transducer can be easily calculated using the Pythagorean theorem.

$$b = \sqrt{c^2 + a_2}$$

where:

b = the effective range of the transducer

c = the range of the side scan sonar recorder

and a = the height of the fish above the seabed.

Table 1 contains all the information used to determine the probabilities of detection as well as the P.O.D.'s themselves.

The first area in the table has the worst probability of detection, but forty-five per cent of it was explored again in later searches, increasing the P.O.D. to 90% in those areas. The remaining fifty-five per cent of the first search area should be re-explored.

The position that was plotted as the "schooner BEAR" had a probability of detection of only .68 for its search area. This low P.O.D. does not exclude it from being a promising target for future searches. In fact, based on the low P.O.D. and the Naval charts, the area should be searched again.

The only portion of the probability of detection determination that has not been researched by this team is the underlying assumptions and probability distributions used by the people who developed the tables in the National Search and Rescue Manual. These should be investigated to see if they truly apply to this type

Search Area	Track Spacing	Scale	Height of Fish Above Seabed	Sweep Width	Coverage Factor	Probability of Detection
Square centered on Buoy (Plot 31)	500 yards	200 meters	100 meters	378 yards	.76	.65
Square centered on wreck B (Plot 34)	500	300	70	639	1.3	.90
Square centered on wreck A	500	300	70	639	1.3	.90
Trapezoid to the right of wreck A (Plot 36)	500	300	70	639	1.3	.90
Lower trapezoid to the right of wreck A (Plot 39)	500	300	70	639	1.3	.90
Square centered over "Schooner BEAR" (Plot 41)	250 yards	300 meters	240 meters	197 yards	.79	.68

TABLE 1

INFORMATION USED TO DETERMINE P.O.D.'S FOR SEARCH AREAS
AND PROBABILITY OF DETECTION FOR SEARCH AREAS
(DERIVED FROM CG-308)

of search, for the technological sophistication of this search was much higher than any previously conducted by the Coast Guard. With the use of the Northstar 6000 LORAN receiver and the EPSCO C-Plot LORAN Position Plotter it was determined areas were covered and exactly how well. This might have some effect on the tables. It is also recommended that a sweep width table be generated for side scan sonar searches.

B. NAVIGATION

This section of the report deals with navigation and data collection concurrently, for a good deal of the data obtained was navigational in nature. The use of the Northstar 6000 LORAN-C set and the EPSCO C-PLOT/LORAN-C Position Plotter in the search for the BEAR will be detailed; the search patterns used, the side scan sonar traces obtained, and the general information kept in the log book will also be explained. The intent of this section is not only to outline what was done on this particular search but to provide direction for future endeavours of this or similar nature.

At the outset of this project it was decided that the Northstar 6000 LORAN-C set would be used in conjunction with the LORAN-C Position Plotter for all navigational purposes. The Northstar 6000 was chosen for its many special features, including the ability to steer a computed line and program destination points into its memory. These two features were thought to be especially valuable to the project, for it was intended that, during the search, the ship would be made to steer to a pre-determined point to initialize the search and from there would be made to steer along a LORAN-C line comprising one of the legs of the search pattern. Actual use, however, proved something quite different than anticipated.

On the pre-search phase of the MAP, when the equipment was being tested in Fisher's Island Sound, the NORTHSTAR 6000 was programmed to have the tugboat that was being used arrive at a precise location in the Sound and, from there, to steer along a LORAN-C line in a search for a sunken automobile and airplane. It was found that it was not very effective to use the loran set as a sole means of transiting or steering along a computed line, for it proved confusing to both helmsman and conning officer as it was often unclear whether the vessel was to the left or right of the computed track. This was due to the fact that the loran set computes a track to a point based upon the destination point and the point at which such a trackline is requested; thus the confusion arises as to whether the "SCL" ("steer computed line") or "SCLR" ("steer computed line reversed") function should be used. With proper explanation, this confusion could have easily been eliminated, but it was not done on the search trip. For ease of steering, the EPSCO C-PLOT/LORAN-C Position Plotter was used along with the loran set.

The EPSCO C-PLOT/LORAN-C Position Plotter, Model 4050-10, was obtained for use in the search for the BEAR for its ability to plot the exact track of a vessel on a plot sheet yielding a permanent record of where the ship has been. It was felt that it would be especially desired when the actual search was conducted, for it would show where the "holes" were in the search pattern, and would allow for accurate return to a specific area. The ability to simply draw a search pattern on a plot sheet and have the helmsman steer along the drawn lines was also seen as invaluable.

During the pre-search phase, the plotter was initially used only to draw a trackline to show where the tugboat had been; at this beginning stage the Loran C set was solely relied upon for navigation. When it was discovered that the loran set could not give the repeatability that was necessary for the type of search that was to be conducted on Brown's Bank, it was decided to use both the loran set and the plotter together. Employing both pieces of hardware offered many advantages: the ability to initialize a plot with the loran C time differences of the vessel's present location to yield a plot of the true trackline being traversed (thus eliminating the need to pre-calculate initialization points of the plot sheets); the ability to simply draw a search pattern on a sheet of paper and have the helmsman steer along those lines, while having a continuous read-out of the loran-C position on the NORTHSTAR 6000; the ability of the helmsman to more easily follow a prescribed trackline, thus avoiding the confusion of having to steer by the "SCL"/"SCLR" function of the loran set, while at the same time providing the OOD with the base course that the helmsman is steering. Due to time limitations on the pre-search phase, the above advantages were merely offered as hypotheses which merited testing before the actual search began. The plotter had been used to a great extent during the pre-search phase and had met with much success, yet the full capabilities of the two together were not investigated. Had the integration of the plotter and loran set been accomplished earlier in the pre-search phase, much time would have been saved when the actual search began in Brown's Bank.

En route to the principle search area in Brown's Bank, the plotter was used only to acquaint the members of the research team with its use and, thus, was limited to merely tracing the track of the USCGC CONIFER to the probable BEAR location. Due to the configuration of the bridge of the CONIFER, the plotter and loran set, as well as the EG&G Side Scan Sonar Recorder, were located in a chart room just aft of the bridge with access through a door on the starboard side. This proved to be a somewhat awkward and inconvenient arrangement, as "course to steer" information had to be passed from the watchstanders in the chartroom to the OOD on the bridge, then from the OOD to the helmsman. The time that it took to pass information in this manner greatly reduced the effectiveness of the sophisticated hardware. Because the cadets did not give the OOD enough warning that a turn was imminent, many turns were executed poorly and resulted in a sloppy coverage of an area. Set and drift, as well as helmsman error, compounded the problem and a plot such as that in Figure 1 (Plot #30) was obtained. Due to the dependence on the NORTHSTAR 6000 initially during the search phase, the plotter's capabilities were not being fully utilized. When the plot sheet was analyzed it was seen that not only were there a great many "holes" that received no coverage at all, but that the track legs were not straight nor were they parallel. It was then decided to draw a search pattern on the plot sheets and place the plotter in front of the helmsman. Thus all the helmsman had to do was steer along the lines drawn on the sheet, which would ensure that the proper track spacing was kept and that the lines would be nearly straight and parallel. As the helmsman became accustomed to using the plotter to steer by, the holes in the search areas became smaller and occurred less frequently, thereby increasing the probability of detection.

At this point it becomes necessary to outline how search areas were constructed and why they were chosen. Utilizing the data obtained from prior research of currents and winds, in conjunction with the information provided from Naval charts of the known wrecks, an area of Brown's Bank was targeted as the most probable location of the BEAR. Creeping line search areas were constructed centered at the positions of charted wrecks. The area covered was a function of time available for the search and estimates on the probability of finding a wreck in the proposed search area. The track spacing was a function of the range of the side scan sonar; a spacing of 500 yards was used for most of the search, as the effective range of the sonar was 200 meters to each side. Using the EPSCO C-PLOT/ LORAN-C Position Plotter all that needed to be done was to draw the appropriate search pattern on a plot sheet, initialize the plotter, and have the helmsman steer the lines. A creeping line pattern with the legs oriented north-south was chosen to cover the large areas of the search due to the simplicity of laying out the pattern and the fact that the long, straight lines of the pattern were easier for the helmsman to follow. When a new search area was entered, a sector search was commenced at the center of the area (probable or charted location of a wreck). The sector search was designed to cover a very small area with maximum coverage in the center, as this was a likely wreck location. The reason for conducting a sector search was to discover the wreck in a shorter period of time, assuming that there was a wreck where the charts indicated. The sector search would have alleviated the need to conduct the more time-consuming creeping line search of the same area had a wreck been found using the former method.

C. DATA COLLECTION

Having discussed the navigational tools employed during the search for the BEAR, from the hardware to search patterns, it now remains to outline what sort of data was, and should have been, collected and how the data was recorded.

With the set-up used for the BEAR search, the data was derived from three sources--the NORTHSTAR 6000 LORAN-C set, the EPSCO C-PLOT/LORAN-C Position Plotter, and the EG&G Side Scan Sonar Recorder. The NORTHSTAR 6000 LORAN-C set provided longitude, latitude, course, speed, and loran C time difference information that could be "memorized" for a location by switching to the memory function. When a contact was observed on the EG&G Side Scan Sonar Recorder, the time and letter designation was noted on the trace and the NORTHSTAR 6000 was switched to "memorize." The previously indicated information was to be logged in the BEAR Project Log, along with a brief description of the contact (how large it was, its shape, and its position on the trace). At the time of the sighting of the contact on the sonar trace, a mark was to be made on the plot sheet in the IPSCO C-PLOT/LORAN-C Plotter with the letter designation and time of sighting of the contact. Throughout the search this procedure was not always followed, which yielded poor data at times. Other information was also important to keep: the time should have been indicated on the side scan sonar trace every five (05) minutes and, on the hour, the initials of the person on watch and the date should have been included; the plot sheets should all have had a title box with the following information-- time the plot was commenced and terminated, the date, the plotter coefficients, the contacts that were on the plot sheet, and the number of the plot sheet (sequential from the time that the expedition began); the legs of the search patterns should all have been numbered and the time that each leg was started should have been indicated on the plot sheet, in the log and on the side scan sonar trace to ease in correlation of the data; the initialization point of the plot sheets should have been clearly marked; arrows should have been drawn on the track legs indicating in which direction the ship was headed on each leg; the time that the blades of the side scan sonar recorder were cleaned should have been noted on the sonar trace, on the plot sheet, and in the log; the loran lines should have been labeled on all plot sheets; and the log should have been kept in accordance with standard log keeping procedures and with the instructions in the log book. All of the aforementioned items were not done properly at all times, this stemming from a lack of understanding among the research team. The search effort and results obtained would have benefited a great deal had the team discussed prior to conducting the search what information it had anticipated obtaining and agreed upon a format for recording the information and correlating it. As it was conducted, the effort was a "learn by doing" affair and thus introduced a great many errors that could have easily been avoided had this very important phase of the operation been discussed by the group.

To summarize, the navigation/data collection aspect of the

BEAR project, thereby offering suggestions for future endeavours of this nature, it is concluded that: the NORTHSTAR 6000 was an ideal loran C set to use as it had the capability of being able to "memorize" the data for any position; the EPSCO C-PLOT/LORAN-C Position Plotter was a valuable navigational tool as it allowed for a very thorough coverage of a particular search area, allowing the "holes" to be readily seen, and it was simple to use; the plotter and loran set were, and should be, used together as they provide ease of data collection; the plotter was, and should be, placed such that the helmsman can use it as his primary input as to "course to steer"; the data should be kept in accordance with a predetermined format and should be checked periodically to ensure that the standards are met; the OOD and helmsman should be thoroughly aware of what is to be done during the search, thereby reducing conflict between the research team and the officers and crew of the ship.

D. RESULTS OF THE SEARCH

This section of the report is intended as a chronicle of the results obtained during the search for the BEAR on Brown's Bank, 60 nm south of Nova Scotia. Prefacing the major portion of this section is a short account of the results of the search for an automobile and an airplane in Fisher's Island Sound, the "testing ground" for the equipment to be used in the BEAR search and for the procedures to be followed.

On Thursday, 28 June 1979, the members of the BEAR search team departed the Academy on board a Coast Guard Academy tugboat en route to a location in Fisher's Island Sound where the Coast Guard Research and Development Center had placed an automobile for the purpose of conducting side scan sonar tests. The research team had outfitted the tugboat with a NORTHSTAR 6000 Loran-C set, an EPSCO C-PLOT/LORAN-C Position Plotter, and an EG&G Side Scan Sonar Recorder and "fish"--all of which would be used in the Brown's Bank search. The loran set and plotter were located on the bridge of the tugboat and the side scan sonar recorder was located on the mess deck aft of the bridge, with no direct access to the bridge. The fish was towed from the stern of the vessel.

Upon leaving the dock, the LORAN-C Position Plotter was used to familiarize the cadet team with its operation and reliability as a navigational tool. A portion of chart no. 13214 (published by the National Ocean Survey of NOAA, 20th ed., May 1977) depicting the entrance to the Thames River and Fisher's Island Sound served as the plot sheet for the day's expedition. Upon arriving in the Sound, the tug was piloted to an orange and white buoy (east of Seaflower Reef flashing light buoy) marking the location of the sunken automobile. Making various passes by the buoy enabled the search team to obtain a good side scan sonar trace of the auto. The fish was towed at a depth of 5-10 meters and the speed of advance during the towing operation was 2-5 Kts. It was found that, due to the physical separation of the side scan sonar recorder and the navigational hardware, an accurate record of a sonar contact could not be kept. It was decided to establish a means of voice communications between the loran set/plotter watchstander and the person stationed at the side scan sonar recorder.

The NORTHSTAR 6000 LORAN-C set was used a great deal during this first search to assess the value of the following special functions: ability to steer a computed line; ability to memorize data such as course, speed, latitude, longitude, and loran C time differences; and the ability to interface with the EPSCO C-PLOT/ LORAN C Position Plotter. It was found that, used alone, the loran set was helpful in arriving at a predetermined destination and in steering a computed course; in conjunction with the plotter the navigational capabilities were greatly enhanced.

On Friday, 29 June, the cadet team set out again to Fisher's Island Sound, this time to search for a sunken airplane. The same search speed and towing depth were used. This search differed from the one of the previous day in that the loran set was programmed to follow selected loran lines which comprised the legs of a creeping line search. The plotter served as an excellent, immediate check on the accuracy of using the NORTHSTAR 6000 loran set as a sole means of steering a desired search pattern. It was conclusively found that the plotter was a better tool for steering a desired track and that the loran set was valuable principally for the time difference, latitude, longitude, course, and speed information that it provided, although it could be used as a check to the helmsman to indicate when he was deviating from the prescribed course. On this day the airplane was found and a record was kept of its position.

Thursday, 5 July 1979, found the cadet team once again in Fisher's Island Sound to test the repeatability of the navigational equipment. It was intended that the airplane would be relocated simply by using the information programmed into the NORTHSTAR 6000. Due to the fact that the destination point was entered into the loran set while at the dock, the course information that the loran set supplied was a straight line that crossed land to reach the destination point. The cadet team did not realize that an error of this type had been made and, ultimately, were unable to relocate the sunken airplane. Upon consulting the loran C manual, the errors of operation were discovered and all of the members of the team were instructed on the details of destination programming to avoid future errors.

The Fisher's Island Sound searches proved to be very beneficial to the search for the BEAR for they not only provided the members of the search team with "hands-on" experience with the equipment before arriving at Brown's Bank but helped to establish operating procedures that would simplify data collection and watchstanding. It was seen that a direct communication link must exist between the loran C set/plotter and the side scan sonar recorder, either by placing them adjacent to each other or by having watchstanders use sound-powered phones. When conducting the Fisher's Island Sound searches, the shallow towing depth necessitated stationing a person on the cable attached to the fish to ensure that no harm came to the fish or cable during turns (i.e., interference with the vessel's propellors). Thus it was decided that, during the Brown's Bank search, there would be three cadets on watch: one stationed near the cable to the fish, one at the side scan sonar recorder, and a third at the loran set and plotter. (It was later found that a "fish watch" was not necessary due to the greater depths of the fish during the Brown's Bank search.)

On Wednesday, 11 July 1979, the BEAR search team departed the Academy aboard USCGC CONIFER en route to Brown's Bank. The data collected during transit time was limited to setting up plot sheets for the EPSCO C-PLOT/LORAN-C Position Plotter and recording course and speed information in the log book; familiarization with all the search equipment was gathered by all members of the search team.

At 0030 on Friday, 13 July, the CONIFER arrived at the position for wreck "A," the primary BEAR search point. A buoy was dropped to act as datum at 42°26.7' N and 065°27.2' W. The following were the loran C time differences: master - 9960, S_1 - 12425.2, S_2 - 43880.0, S_3 - 25180.4, S_4 - 60332.5. The fish was lowered into the water but, due to eqipment failure, the search did not commence until 0430. A north-south track line was followed, but a search pattern was not drawn on the plot sheet. Thus the helmsman was asked to follow a particular course. Set and drift, as well as helmsman error, produced a pattern such as that shown in Figure 1 (plot #30). This was not adequate for our needs and it was then decided to place the plotter in front of the helmsman to have him steer the lines of a drawn search pattern.

The initial passes by the datum buoy yielded one side scan sonar contact, contact "A," at 0541 on 13 July. It was evaluated and determined that it was not a ship but a thermal line. The subsequent search around the datum buoy was constructed as a 5x5 nm north-south track line search with 500 yard track spacing. As the track legs were not numbered, the pattern was accomplished in a hap-hazard manner, thereby leaving many "holes" that received no coverage (Figure 2 (plot #31)). This 5x5 nm area was chosen as it seemed probable from historic and oceanographic data that the <u>BEAR</u> might be located in this area. The search of this area commenced at 1229 on 13 July and was terminated at 1410 on 14 July. Ten (10) contacts were recorded during this time but, upon evaluation, it was determined that they were either thermal lines or bottom contours (i.e., ripples, rocks).

Contacts "A" and "G," found during the search centered on the datum buoy, were of slightly different characteristics than the others and it was decided that, before moving on to a new search area, another pass would be made around each. The coordinates of contact "A" are: $42^{o}28.2'$ N, $065^{o}27.3'$ W, S_1 - 12417.9, S_2 - 43886.3,

S_3 - 25184.2, S_4 - 60297.6. The coordinates of contact "G" are: 42°25' N, 065°25' W, S_1 - 12429.5, S_2 - 43872.1, S_3 - 25176.3, S_4 - 60308.4 (this figure is questionable). A sector search around each of these contacts was constructed, with seven 1000 yard track legs. (Figure 3 (plot #32)). The "holes" of the previous search pattern were also covered during this search. During this time (1416-2335 on 14 July) two additional contacts, "L" and "M," were discovered. Contact "L" proved to be only a thermal line. Contact "M" was of interest to the search team for it displayed a "ripple" characteristic and had shadows--potentially a wreck. Several passes were made over the area of contact "M" (42°24.9' N, 065°27.1' W, S_1 - 12433.8, S_2 - 43872.6, S_3 - 25176.2, S_4 - 60278.3) but nothing further was found. At 2335 on 14 July the search in area "A" was suspended and the team began a search centered around charted wreck position "B."

The search around wreck position "B" was commenced at 0130 on 15 July. It was composed of a 5x5 nm creeping line search pattern with 500 yard track spacing (Figure 4 (plot #34)). Six (06) contacts were discovered between 0130 and 1600 on 15 July, but none merited a concentrated search. In the morning of 15 July it was discovered that the datum buoy was placed in a position that did not correspond accurately with charted wreck "A." The error arose due to the scale of the chart being used. The position of the datum buoy was approximately 2 1/2 nm east of charted wreck "A"; therefore wreck "A" had not received adequate coverage. It was decided at 1600 to terminate the search of wreck "B" and recommence the search at wreck "A."

A sector search around "A" was commenced at 1610 on 15 July. The sector was composed of six 1500 yard legs and was chosen to expeditiously cover the area around the wreck before a creeping line search was initiated. (Figure 5 (plot #35).) At 1732 a contact, contact "H," was discovered (S_1 - 12432.7, S_2 - 43886.0, S_3 - 25182.8, S_4 - 60280.7). Several passes over this area yielded no additional sightings. At 1912 the sector search was completed and a creeping line pattern was initiated at 1933.

The creeping line pattern was composed of north-south track lines at a track spacing of 500 yards. The shape of the search area was trapezoidal. This shape was chosen to fit the probability of location curves drawn on chart 13009 of the National Ocean Survey (NOAA) by the group's oceanographer; by taking away the upper left corner of an otherwise square search area much time was saved and an area where the probability of location was low was thus not covered. (Figure 6 (plot #36).) Five (05) sonar contacts were found but none were evaluated as being a wreck. The trapezoidal area encompassing wreck "A" was terminated at 1048 on 16 July when it was decided to re-investigate contact "H" of 15 July. Several passes were made of the area around contact "H" (Figure 7 (plot #38)) and, at 1141 on 16 July, another contact was discovered. Designated contact "E," its coordinates were: 42°27.3' N, 065°31.1' W, S_1 - 12433.7, S_2 - 43886.2, S_3 - 25182.9, S_4 - 60269.3. The agreement between the Loran C time differences leads to the conclusion that contact "H" of 15 July and contact "E" of 16 July are one and the same. It was later determined that these contacts were bottom features. At 1526 the search around wreck position "A" was terminated and a trapezoidal search adjacent to the previous one was commenced at 1530.

The second trapezoidal search was of the same dimensions as the previous one and was located south of the former (Figure 8 (plot #39)). This search was conducted because it fell entirely within the circle of probable detection of the BEAR based upon weather and sea conditions at the time of sinking. Two (02) contacts were discovered but they were evaluated as bottom features. As the search was to be terminated by 1200 on 17 July, and as no substantial contacts had yet been discovered, it was decided to terminate the search in the area south of wreck "A" and proceed southwest to a position marked as "schooner BEAR" on naval charts and in naval publications.

The search at the position marked "schooner BEAR" was a creeping line search 1 1/4 x 1 1/4 nm square, with a 250 yard track spacing (Figure 9 (plot #41)). The reduced track spacing was due to the decrease in the range of the sonar because of the depth of the water at the search location. The search of this area began at 0025 on 17 July and was terminated at 0818 on the same day. No contacts were discovered. The coverage of this area was poor due to the depth of the water and the difficulties involved with such a compact search pattern. At 1112 on 17 July the fish was raised and the search for the BEAR was terminated.

At 1145 a camera furnished by Dr. H. Edgerton of M.I.T. was put into the water to take pictures of the bottom.

IV. USE OF VIDEOTAPE EQUIPMENT FOR DOCUMENTATION

As the BEAR search project was shaping into a reality, the idea of recording the progress of the project in the form of a video essay was introduced. The task included all aspects of the project, starting from the moment the MAP was introduced to the class of 1980 up until the final days of work on the project. Thus, this portion of the project was begun before any other, recruiting the help of the audio visual club until the team was chosen and the job assigned. Two cadets from the BEAR team were tasked with the producing this report. From then on, an account was kept of the progress being made throughout the semester in addition to video-taping various aspects of the work. As the semester came to a close, work on the project came to a temporary halt while the cadets went to sea on summer training cruises. June 27th brought the team back together again to pick up where they left off on the project. Work was begun in testing the equipment and building marker buoys. The cameras followed the cadets through their work and tests with both video and still shots. This also provided an opportunity to test the video equipment underway on the Academy T-Boats in Fisher's Island Sound.

The most important part of the video essay was the search itself. The cadets boarded the USCGC CONIFER with not only the equipment necessary for the search, but also enough video equipment to preserve the week's activity on film. The equipment included a color camera outfit with video tape deck and 12" color monitor, a protable video tape deck, a lighting kit, tripod, tape recorder, microphones, and necessary tapes, batteries, cables, and adapters. After discovering equipment failure in the portable unit, it became even more critical to find a centrally located spot for the tape deck from which cables could allow the camera to move around the ship. Fortunately, just such a place was found quickly in the after towing room in the deck house. The tape deck and monitor were secured there while the camera operator was free to roam about the ship. Every aspect of the project was recorded from the leaving of New London, the raising and lowering of the fish, watch-standing, and recreation to the ship's arrival in Portland. The tape recorder was easily carried anywhere on the ship and added much to the documentation by recording conversations of the team and the crew.

The cadets assigned to the video essay had to work on it during their off watch hours. They stood bridge and sonar watches on the same 4 hours on/8 hours off rotation as the rest of the team. To facilitate getting desired still shots of the search, all other team members with cameras were provided film to preserve sights of interest during their off watch hours. This was great help to the video team who were not available at every moment. As the search came to a close, and the equipment, cadets, ship, and crew were returned to their respective places, the video history also came to a close. After arriving in New London, the video team sat down to outline the program, write a script and begin the tedious task of preening, cutting, and overdubbing the film, deciding how to successfully convey how much work, learning, enthusiasm, and cooperation went into making the search the success it was.

There were some problems encountered by the team in taping the essay. While the cadets in charge of video were responsible for the essay, they were also responsible for learning about the other equipment, participating in every other aspect of the team's work, and standing watches on the ship. This made them unavailable to film any events that took place while they were on watch and also put a great demand on their free time. A better situation would have been to have had the two cadets on video being permanent dayworkers which would have enabled them to put together a more comprehensive project history. By then grading them solely on their performance with the film, they would have had the freedom to devote the time necessary to make a really worthwhile film. Their MPA, then, would have been in video, not the <u>BEAR</u> search. But while the two MAP's would be working together, their free time could be used to find out more about the <u>BEAR</u> search instead of the other way around.

As far as the equipment went, most of it worked well. The monitor was very useful in providing immediate feedback on the quality of the film being made. The portable unit was a good idea, but could not be used due to a malfunction in the machine. The lighting kit was valuable in supplementing the ship's light sources. Probably the most important aspect of being able to work effectively was having a centrally located spot out of which the equipment was operated.

One piece of equipment which was not used, but would have been a great aid to the documentation was a 16 mm camera. This camera is very portable and would have enabled the cadets to get closer to the action. Sixteen millimeter film requires a lot more work when putting together the final video program because it requires the use of film chains which involves filming from 16 mm film on to video tapes. However, that time could be better spent after the search than on the ship where things happen quickly and taking the time to set up a video camera and tape deck may mean missing the shot. This is where a 16 mm camera would prove invaluable. Its quickness would keep those shots from being lost.

Thought must also be given to the amount of time necessary to put together a finished video program. It must be realized that the remaining work days at the end of the search are not nearly enough to complete such a task. Developing the 35 mm film alone requires more time than this. A high quality video history could easily take an entire semester to complete.

V. REVIEW OF THE PROJECT FROM A MANAGERIAL STANDPOINT

This section of the report does not necessarily fit into the scientific flow of the rest, but none the less it is felt to be a necessary portion. This section is not meant to find fault in any way with the method by which the team was run this year, for the "interdisciplinary team concept" is something new to Academy MAP's and for an initial try the results were satisfactory. This is written, though, in the hope of bringing to light the pitfalls and problems which were encountered so that groups to follow, should they be formed, may correct for and avoid mistakes in the areas of team selection and interaction. This action will also try to provide some insight, based on the team's experiences, into possible corrections of the problems which were encountered and some leadership styles and traits which it is believed should be looked for and practiced by future groups.

The group dynamics problem that this year's team encountered stemmed from two main areas: first, the lack of attention given to personality matching in the initial group selection, and second, to the failing of the group leader to control the small informal groups that formed so that the team could function as a whole. This section will first look at the area of group selection.

The selection of this year's group was done in the following manner: first an announcement was made to the Class of 1980 that a MAP would be offered to search for the cutter BEAR, along with a brief description of the program. A sign-up was then held for all those cadets who were interested in becoming a member of the team. In all, approximately 30 cadets signed up for the program, 12 of which would be chosen to participate.

It is in the next step of the selection process where improvements could definitely be made. The twelve cadets, who were chosen to comprise the team, were selected on the basis of grade averages, with one or two cadets coming from each academic major. This method, although it may have gotten the "best" individual parts for the team, did in no way insure that synergy would be present.

Those traits of members which are seen as being necessary in order for the team to function at its highest potential will now be investigated.

The first of these traits is a sincere interest in the project as a whole and the willingness to make individual sacrifices for the benefit of the group. In order for the group to succeed it takes a strong team effort. In the group some individuals had a specific task assigned to them that was essential to the smooth operation and completion of the project--if they failed the group's efforts as a whole were hindered.

The second necessary trait is the ability to work closely and participate with other group members. One aspect of this trait which cannot be over emphasized is the ability to both teach and learn from your peers. The group was set up so that a team member was given the task of researching, learning to operate, and instructing others to operate a particular piece of equipment. If he, through lack of understanding, patience, time, or skill could not accomplish this, the group as a whole suffered for it. A second aspect is an ability to hold an open view of other's ideas. Some team decisions were made by "brainstorming" and a narrow view is never an aid during this type of activity.

It could be said that the central criterion in selecting personnel to comprise the team should be that they will be an aid to and bring about group cohesiveness. The consequences of this cohesiveness are as follows: (1) maintenance of membership: if a highly cohesive group is chosen the chances of its losing members and having to fill gaps is minimized; (2) the power of the group over its members is increased: studies have shown that in groups with higher cohesiveness there is more of a conformance to group norms caused by the fact that members more readily exert influence on one another and are more readily influenced by one another; (3) participation and loyalty: several studies have shown that as cohesiveness increases there is also an increase in communication and participation and a decrease in absenteeism; (4) personal consequences: members of a cohesive group have a sense of security, reduced anxiety, and a heightened self esteem.[1] The group that was chosen fell short of being cohesive, the causes of which will now be presented.

The first of these causes which can be entitled the "I am an expert" syndrome, befell us largely as a result of the initial tasks and equipment to which team members were assigned to become "experts" and instructors in. The fact that the team member's major in many cases correlated to the task or equipment assigned also contributed to the problem. People in many cases became protective of their piece of equipment and were reluctant to let others use it. It must be remembered that they were trained on that equipment so that they could teach others, but at times this objective fell to the almost maternal protectiveness of the "expert."

A second pitfall that was encountered was one common to most organizations--a lack of communication. Many misunderstandings and harsh words could have been avoided if one hand had only known what the other was doing. A few times people were unaware that a specific task was expected of them because they were not informed causing hard feelings between both parties involved. A large cause of this lack of communication was the formation of several informal sub-groups. These groups for the most part were split down academic-major lines. Along with these came several "informal leaders." In order for the team to function at its fullest potential it must work as a single unit with a common goal, not as three or four small units each with their own goals. The question will now be addressed of what can be done in future groups to improve the encountered problems. It will be addressed in three parts, the first of which will be group selection.

The first question of concern to group selection that must be answered is "Is there a need for an interdisciplinary group?" The consensus of the group answers "no" for the following reasons. First, all of the equipment was used on an operator level only.

This means that it did not take an EE major to operate the loran nor an ocean engineer to put over the buoys. The Academy curriculum is set up in such a way to give everyone a well rounded education and none of the team had had enough courses specifically within their major to be considered specialists. Therefore, in light of the fact that a better personality mix may be possible by ignoring academic lines, it is recommended that in the future the inter-disciplinary aspect of the team be relaxed as much as possible.

The second question that must be resolved is that of team size. The ideal group size would be one that utilized the minimum number of people who could still accomplish the task. It is believed a group size of approximately six would be ideal for the purpose. With a group of this size the communications problem would be drastically reduced, the tendency for sub-groups to form would be lessened, group cohesiveness would be improved, but there would still be ample people to accomplish the work. With the size of this year's team, people had idle time on their hands for lack of things to do.

The next question to be addressed is the method of group selection once the initial sign-up is held. As was previously stated, this year's method of using grade point averages produced a less than optimally cohesive group. Again it must be stressed that the thing of the most importance in the selection process is for the group to be able to work as a whole. For the most part, by the time first-class-summer arrives an Academy student has had numerous occasions to work with his peers and is aware of those with which he is capable of working closely. For this reason it is thought to be very important for the students to have more of a say as to who comprises the team. One possible method of achieving this would be to have each person choose five other persons, in order of preference, that he would best be able to work with. A compilation of these lists could be used to determine the best mix for a cohesive group. Interviews should then be held with these people to ascertain whether they have a sincere interest in the project, they understand what will be expected of them, and they have the necessa;y time to devote to the project. Again, this method is only a suggestion, the important point is that personalities and compatibilities are matched--not grade points.

This concludes the discussion of group selection and what follows will be a look at leadership in an undergraduate research project.

Of all the topics studied while looking at the nature of groups, the role of leadership has been studied more often and in more depth than any other. For decades men have believed that morale, group effectiveness and leadership are all closely tied together. Yet as time has gone on, as more information is gathered, it appears the correlation of these three aspects of group dynamics is becoming more complex. Although the belief that team effectiveness can be achieved through a "good" leader has lost some of its followers, it is still one of the most prevelant ideas of modern management.

The characteristics of a good leader will vary from situation to situation and from group to group; good leadership is dependent upon the way a situation is handled rather than the traits of the leader. There exist no typical traits of a good leader; a good leader is instead the person who can deal with specific and varying situations, people, problems, and time constraints. This section on leadership was, and is not meant to define the characteristics of a good leader but instead to point out the problems which will arise and which the leader will have to deal with.

An undergraduate project of this sort will usually be initialized by some person who has some background or interest in the work which is to be done. This man is the first leader and will be the first one studied. As the instigator of the project (referred to as project director from now on), the man who has the original idea and causes the group to be brought together has a critical role in getting the research off to a good start. Aside from having the power to select the group, the project director has the idea in his head of what work needs to be done and what the purpose of the project is. There exist basically two ways in which the project director can get the work going: first, he can pass the information out himself or second, he can work through a "group" leader, a majority leader selected by the project team.

Looking at the first alternative, it is easy to see many advantages to it. Of the advantages, just to mention a few, there is ease of information passing, no middleman, he knows exactly what he wants done, and when he has to have it done. It is because of the quickness with which information can be passed that makes this a very good arrangement for the start of the project. In the beginning of the research many members don't know what they should be doing or even how to do it. In order to prevent the initial excitement of the project from wearing off quick action must be taken to ensure that people remain motivated and redirect their excitement into work. By having the project director get things moving you will be able to avoid a confused feeling, among the members, over what has to be done. The project director knows what has to be done and should take the initial action to get work started. It is now important, however, to point out that the project director should in no way be expected to lead the project from start to finish. The director must let each team member become familiar with the things that have to be done and what the overall picture is. By doing this he will be able to let each person see where their work fits in, will keep motivation higher, and can slowly work himself out of the picture. At this stage the project director should ask the group members to select one from among them to take over as a "group leader."

The purpose of this "group leader" will be to allow the cadets to take over the project on their own. By having the group leader work with the director both will be able to see problems that exist with schedules and with working arrangements. The project director will be able to groom the cadet leader to inherit the job of project director. This will be a slow process and may never even be completed, yet an effort must be made to do it. It is critical that a cadet leader exist because of the problems that will often arise in groups of this sort. The first of the problems that will be countered by a group leader will be the lack of communication between officers and cadets. By fact of the work, a superior-subordinate situation is not ideal for the free flow of ideas. It should be the job of the group leader to convey messages and problems from above and below to those who can correct them. He will be, or should be, concerned with the meeting of schedules and even with the setting of schedules. By working with his peers he will have the advantages of knowing their problems and time constraints; while working with the project director he will know the constraints that must be met for the project to be successful. Being in a middleman position he should try to balance out this working arrangement so that each area, and all people involved will be satisfied. The important point is that he will not set unreasonable deadlines but nonetheless will insure the job gets done.

A second job, and perhaps an even more important one for the group leader will be the solving of conflicts. These conflicts will be the result of informal groups which are bound to spring up among the members of the formal group. By fact of the selection process and the very nature of the work, the project team will be formal; however, with what may result in any formal group, smaller informal groups may and will form. It is of critical importance that the group leader remain aloof of these groups and try to insure that the attitudes of the informal sections toward each other, individuals, and the project as a whole are in no way destructive to the end result. If an uncohesive group is formed the conflicts which may result will surely be disruptive and the group leader will have to step in. By fact of his position and the conditions he governs, the group leader must realize he has tremendous control over the motivation and working environment of the other members. It is up to the elected leader to see problems arising and take action to prevent them. The group leader will have to be a trouble shooter, of sorts, for the team. He will have to guard against low morale and social conflict. Because of the work that he is doing the leader must be dynamic and active in the solutions of team problems and must stand a constant watch over conflict. He must be realistic and actively direct the group to solutions of problems.

It can be seen that in the absence of a cohesive group the presence of a strong leader can offset the lack of unity. A strong leader in a group of this sort can help it to overcome conflict and direct it to complete tasks on time. The traits that are necessary for a leader to be effective will vary from group to group depending upon the individuals who make up the group, but an effective leader will exist in every group.

Of the many ideas which were brought out in this section, the one which should stay with the reader is that the most difficult person to work with is your peer. Aside from the fact that you are working with your peers, a group of this type can function well as a team; it is just important to be on the guard for problems. It is hoped that this section will serve as a guide to prevent any major problems from developing in other projects of this nature.

VI. RECOMMENDATIONS

In the course of the project several problems arose. Many of them may seem small, but all are important. These problems should be corrected for any future BEAR search. The following is a list of solutions:

1. Many problems arose in the area of data collection. In order to prevent future problems, it is advised that the section of this report on "Navigation and Data Collection" be reviewed. Many suggestions were made in that section and it is not felt that they need be repeated here.

2. It is felt that the group size, for the project, should be reduced to six. This will prevent many problems from developing because of informal groups; yet, it would allow two people to be on watch with a one in three watch rotation.

3. The idea of an interdisciplinary group should be aborted. The uncohesiveness resulting from this concept interfered with the project. The idea need not be abandoned if a greater knowledge in their field is required than that required in this project, but it is felt that will not be the case.

4. The probable location of the BEAR should be redetermined using all of the available information. Naval charts were relied upon too heavily.

5. The following recommendations are made for the buoy

system:

a. Use two radar reflectors on the buoys to increase the visual picture on the ship's radar.

b. Double nut the bolts on the buoys to ensure that they do not come loose.

c. In preparation for the deployment of the buoys, fake out the nylon line into boxes and tie some of the bites off with thread; this will prevent the line from getting fouled and will greatly ease working with the buoys.

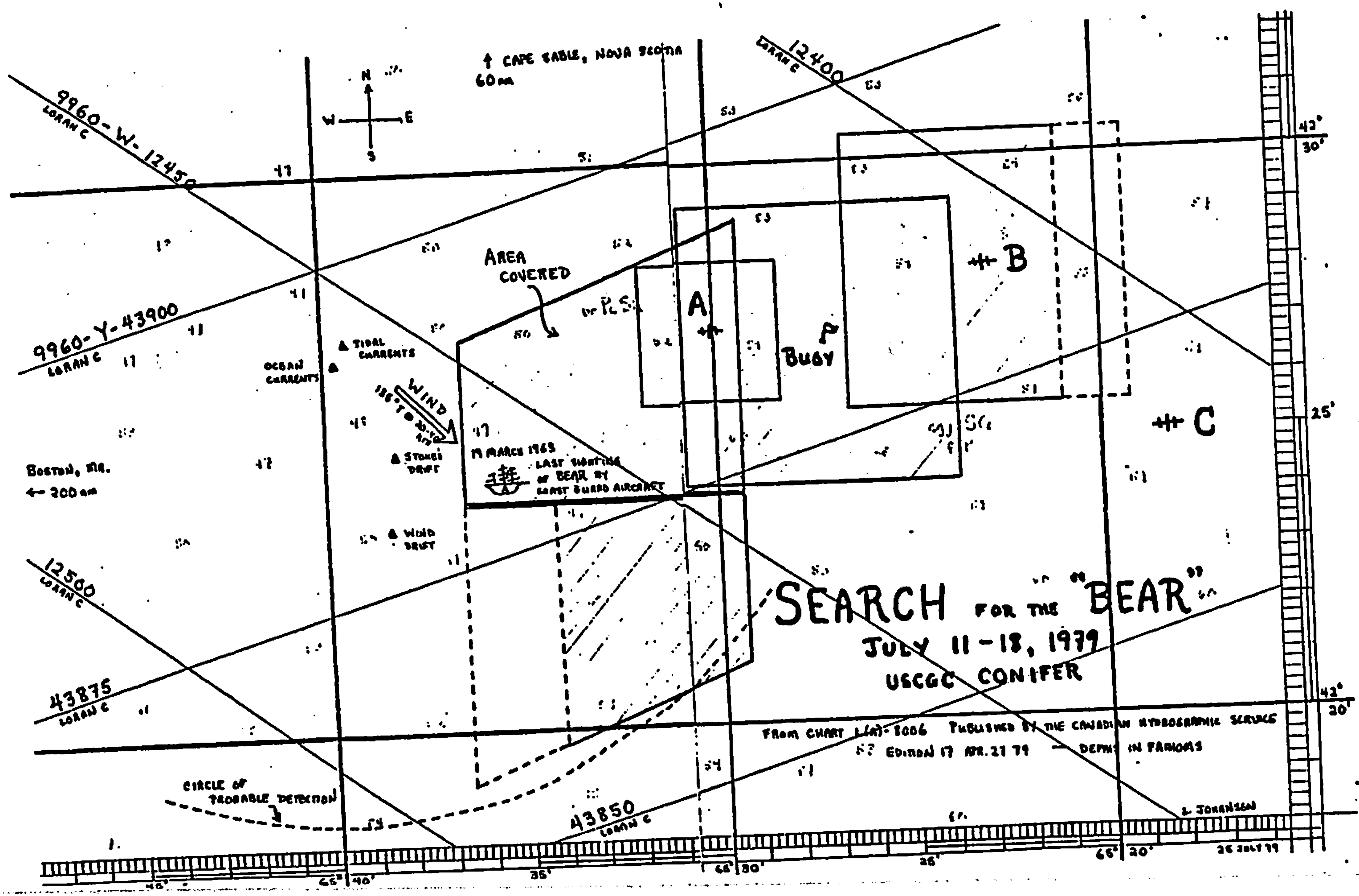
6. A 600 meter cable for the fish tow should be acquired. This will enable the search to be conducted in deeper water with a high probability of detection.

7. Experimentation must be performed on the C-Plot 2 LORAN-C Position Plotter. This machine's capabilities may far exceed those of the plotter employed on this present project.

8. At least five days of practice should be scheduled prior to departing on the search. This can be done with the Academy's T-Boats possibly searching for the sunken U-boat in the sound. Each practice run should be debriefed and problems worked out by the group.

9. It is recommended that a semester project still be taken by the group, but only auditing credit should be given. This project should include learning how to use the equipment and repair it, the use and function of the SAR manual, the construction of tables for the SAR manual, and the redetermination of the most likely position of the <u>BEAR</u>.

10. In order to make a proper effort on the actual search for the BEAR much more time must be spent on the search phase of the operation. A reasonable amount of time would be thirty days or more. Without this time a proper understanding and respect for underwater searches cannot be gained. With this amount of time the BEAR would stand a better chance of being found.



SEARCH for the "BEAR"
JULY 11-18, 1979
USCGC CONIFER
From Chart L(A)-8006 Published by the Canadian Hydrographic Service
Edition 17 Apr. 27 79 — Depths in Fathoms
↑ CAPE SABLE, NOVA SCOTIA 60 nm
BOSTON, MA. ← 200 nm
N
S
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9960-W-12450 LORAN C
9960-Y-43900 LORAN C
12400 LORAN C
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43875 LORAN C
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AREA COVERED
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B
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BUOY
WIND
TIDAL CURRENTS
OCEAN CURRENTS
STOKES DRIFT
WIND DRIFT
19 MARCH 1963 LAST SIGHTING OF BEAR BY COAST GUARD AIRCRAFT
CIRCLE OF PROBABLE DETECTION
L. JOHANSEN
26 JULY 79
42° 30'
42° 20'
25'
66° 40'
35'
66° 30'
66° 20'

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EPSCO C-Plot 2 LORAN-C Position Plotter Operator's Manual.

EPSCO LORAN-C Position Plotter. Coefficient Table for 9960 SS4 Chain W and Y Slave Stations.

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Mark 1B Side Scan Sonar; Bulletin 2-210; EG&G Environmental Equipment Division, 151 Bear Hill Road, Waltham, Mass. 02154.

Cadet Team To Search For BEAR

by Cadet 2/c Stephen B. Glynn

An enterprising group of cadets — led by the man who located and photographed the remains of the MONITOR — are planning a similar search for the wreck of the famed Revenue Cutter BEAR on Brown's Bank south of Nova Scotia this summer.

As far back as anyone remembers, Academy teams have been called "The BEARS"— mostly because of the series of OBJEEs who have served as their mascots, but perhaps also because their Service's most famous ship was the BEAR.

In recent years a new term, BEARMANIA, has been coined. It describes (sort of) the wild enthusiasm and solidarity cadets traditionally demonstrate in support of their athletic teams.

A new cadet venture involving both BEAR and BEARMANIA is now shaping up. This summer a group of cadets, under the tutelage of faculty experts, will attempt to locate the wreck of the BEAR on the ocean floor on Brown's Bank, south of Cape Sable, Nova Scotia. If they succeed, they then plan to photograph her and hope to retrieve from her some significant artifact, to be carried in a place of honor on the new BEAR — one of the highly sophisticated new 270′ cutters now under construction. There is even some speculation that if the BEAR is found reasonably intact, she might ultimately be raised, restored, and preserved as a memorial to our great nautical past. Whatever happens, the cadet team is applying tremendous effort, talent, and BEARMANIA enthusiasm to the project — so much so their principal advisor, CDR Sandell, is finding himself hard-pressed to keep up with them.

You may not be familiar with the history of the BEAR. Roger Olmsted, writing in *American West*, characterized her as "the greatest ship in the history of the West, perhaps the greatest ship in history." She brought Admiral Byrd to the Antarctic, saved the lives of nearly 300 whalers who were entrapped in Arctic ice in 1897-98, helped capture a German spy-ship in World War II and saved the Greely Expedition when it was stranded in the Arctic. Of her sinking, some old salts have remarked that she preferred to die at sea, with honor, rather than face the humiliating future which awaited her as a restaurant on the Philadelphia waterfront. She had been under tow from Nova Scotia, where she had been decaying in an old shipyard when her final hour came. It was the 19th of March 1963, in a nor'easter that proved too much for her poorly repaired hull. The towline parted, her foremast carried away, and her uncalked seams shipped increasing quantities of sea water. She settled deeply and began to founder. The Coast Guard Air Station at Salem, MA, dispatched the HU-7227 to the scene. Pilots E. L. RAHN and P. L. LAMB reached the BEAR by 1140 that day, and, after assisting in the removal of two men who remained on board, circled overhead in a final salute to the great ship. At 2310 that evening the BEAR quietly slipped beneath the waves, leaving nothing to mark her tomb.

You probably have heard of Dr. Harold Edgerton, the expert in underwater technology who was instrumental in finding and photographing the civil war MONITOR, utilizing side-scanning sonar and stroboscopic light. Now a Professor Emeritus of MIT and an old friend of the Academy, Dr. Edgerton became aware of the story of the BEAR through one of his former students, Dr. Lloyd Breslau of the Coast Guard R&D center. He approached the Academy with an offer to help us locate and photograph the great ship in her final resting place.

The exciting and attractive prospect evoked an immediate and enthusiastic response. Assoc. Prof. Paul Johnson, the Academy's Librarian/Curator, was ecstatic. A long time BEAR buff, Prof.

Although the search will be an exclusively cadet project, interdisciplinary guidance and advice will be available from (l. to r.) CDR Hotchkiss (navigation), CDR Sandell (MAP coordinator), PROF Edgerton (underwater operations) and CDR Skinner (ocean engineering).

Johnson had been advocating for years that the great ship be located — and ultimately salvaged. Faculty members CDR Skinner and CDR Sandell (both PCTS) saw it as a great opportunity for the blending of interdisciplinary education and cadet training. Upon receiving conceptual approval from the Superintendent and Dean, they called for volunteers from the Second Class ('80) to comprise the inter-disciplinary team to plan the search and to carry out the plan as part of their regular Mission Area Program (MAP) training for first-class summer. This is an exceptional opportunity for the cadets involved to gain experience in precision navigation, deck seamanship and search procedures as well as practical technical training in the use of side-scan sonar.

The team will all be operating the equipment and doing the navigation this summer, but before we actually get out on the water, we have a great deal of work to do on shore. To use Dr. Edgerton's equipment in a tight search pattern (only a 200 yard track spacing), we must have a relatively good datum from which to search. This means sifting through large amounts of information on the BEAR's sinking. Our problem, in essence, is to locate a wreck of the approximate displacement of EAGLE in a poorly defined stretch of ocean more than 300 feet deep after it has been subjected to current and sedimentation action for more than 16 years. The platform for our operations hopefully will be an east coast buoy tender.

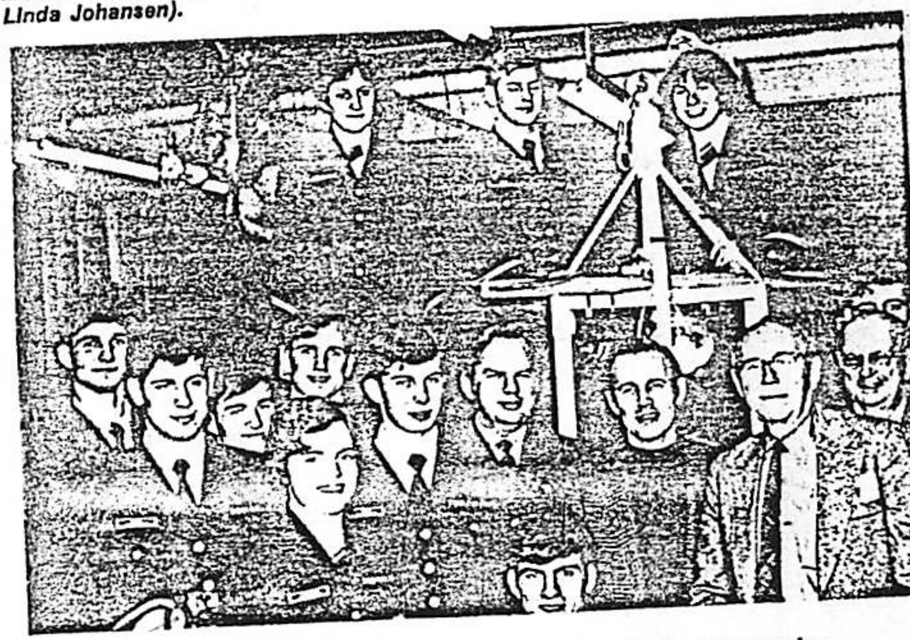
We have been covering a wide variety of research, adding to it the insights we bring from our particular academic specialties. Cadet 2/c Mike Inman, a marine science major, has been gathering information from Canadian authorities on the deep water currents and sedimentation in the Browns Bank area. CDR Hotchkiss and LT Bohan are helping Cadet 2/c Linda Johansen and Cadet 2/c Bob Wilson with the search problem. They have been able to obtain a special bottom chart of major wrecks for our use. Since we will have to depend on electronic navigation, Cadet 2/c Paul White and CDR Hassard (electrical engineers) have been working with the navigation team to integrate these aids with the sonar record to provide a constant plot and accurate, repeatable position data. Cadet 2/c Dale Streyle is obtaining a computer search of all government documents pertaining to underwater searches in order to expand our fund of information. Although we will all receive hands-on experience in using the side-scan sonar, the engineering team (CDR Skinner, LCDR Luckritz, Cadets 2/c Jack Cline, Michelle Fitzpatrick, and Daniel Riehm) are studying the operating principles, capabilities, and limitations of the equipment in depth to provide back-up expertise. CDR Sandell and Cadet 2/c Dave Gosselin are coordinating the team's activities and keeping us on schedule. LT Neas and Cadet 2/c Jack Gunther are keeping us within budget. The author has been busy with historical research and authenticating published positions of the BEAR's wreck with first-hand accounts.

The team recently made a field trip up to MIT to talk with Dr. Edgerton, our chief advisor. He generated instant rapport with everyone. In addition to demonstrating the side-scan sonar, he showed us his pioneering work in stroboscopic light and photography. He gave us an introduction to the operation of the side-scan sonar and an extensive lecture on its use and the interpretation of its traces. His experience and the experience of his co-workers will prove invaluable to our project.

We are all very enthusiastic about the possibilities for the search. It will not be easy but we expect that there are many people besides ourselves who are hopeful that BEAR will be found. If you have any information on her that you think will be helpful in the search, we would appreciate having it sent to either myself or CDR Sandell at the Academy.

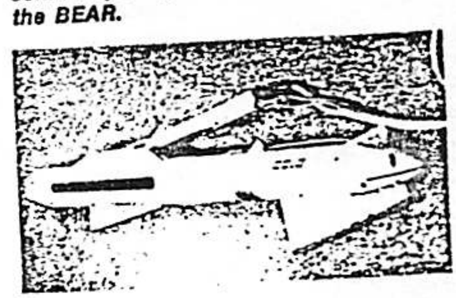
Perhaps in a Fall issue of *The Bulletin* we can show you some photos of this legacy from our proud past. BEARMANIA is contagious — it spills over into all aspects of Academy life. ■

The cadet group pose with PROF Edgerton (right foreground) during their meeting at MIT. Project Leader is Cadet 2/c Dave Gosselin, 4th from left (behind Cadet 2/c Linda Johansen).

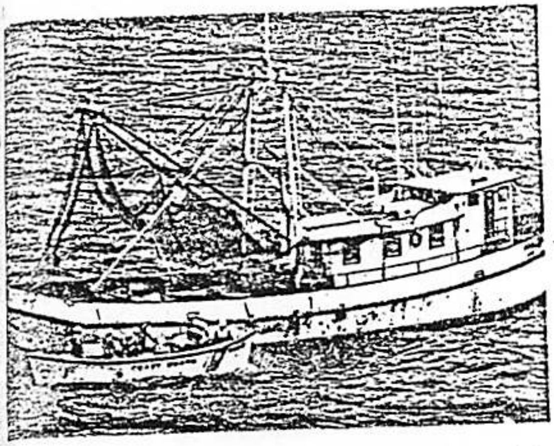


"Most happy fellow" is Librarian/Curator Paul Johnson, an ardent BEAR buff.

PROF Edgerton's side scanning sonar hopefully will locate the BEAR.



CADETS COMPLETE FIRST "OPERATIONAL CRUISE"



A squadron of four Coast Guard High Endurance cutters returned to New London 24 July, completing a cadet training cruise that commenced here on 23 May. Breaking away from the traditional summer cruise to Europe, this year the cutters spent the training period supporting the Coast Guard Drug/Law enforcement efforts in the Caribbean. Although the training of cadets remained the primary mission of this cruise, the cadets were exposed to a number of real life operational evolutions as well. These included two search and rescue cases, the seizure of four vessels enroute the United States with a total cargo of more than 70 tons of South American grown marijuana, and the boarding of a number of foreign and domestic fishing vessels.

While in the Caribbean, port calls were made at San Juan, Puerto Rico; Barbados, West Indies; and Curacao and Aruba, Netherlands Antilles.

The cruise was divided into two five week training periods with a total of more than 300 first class (senior) and third (sophomore) class cadets participating. Meanwhile, some 300 other cadets (two contingents of 150 each) were sailing EAGLE on a coastwise training cruise which included stops in Halifax, Norfolk, Washington, New York, Bermuda, and Savannah.

These summer training cruises are an integral part of the development of the cadets' professional competence as future Coast Guard officers. In addition to the operational experiences, cadets took part in major exercises and multi-ship evolutions such as underway replenishment, towing, helicopter operations, and gunnery shoots. They routinely participated in General Quarters and ships emergency drills and completed self study professional qualification programs as well. On EAGLE, of course, they *sailed*. The teamwork, leadership, and training opportunities aboard a square rigger are limitless.

WE KNOW WHERE IT ISN'T!

by Cadet 1/c Stephen Glynn

In the last issue of the *Parents Newsletter* you read that after months of preparation, the search for the BEAR had gotten underway. Now the "BEAR" team of 1/c cadets is back and can cheerfully report that they achieved their number one goal; gathering valuable experience and training. No, they did not find the BEAR. But, in the words of Dr. Harold Edgerton, the MIT Professor Emeritus who accompanied the group: "If you had found it in eight days you would have thought that this searching is too easy." He also commented that it sometimes takes months to find a wreck such as the BEAR.

Although the BEAR wasn't actually found, the group made some remarkable achievements. This was the first attempt to locate a sunken ship in deep water, out of sight of land. Even if it were close to land, with the "pea-soup" fog the group encountered the entire time it was out it would have made little difference. Instead of the visual and short-range navigation techniques used in earlier searches, the team utilized a digital "computer chip" technology LORAN-C receiver interfaced with a true plot, digital, electro-mechanized plotter. Using these two pieces of equipment, position determinations to within approximately fifty yards could be made. In addition, the main unit contained such useful functions as: time differential memorization, automatic speed over ground computation, and steering information display based on a pre-programmed destination. By placing the plotter in front of the helmsman, he — and the OOD as well — had a graphic display of the ship's motion; hence, once a search pattern was placed on the plotter, the helmsman could steer down each search leg as if he was steering a video "car" in a penny arcade. Without this ability, accurate and complete searches would have been nearly impossible. As it was, approximately 70 square miles of ocean were covered with an overall probability of detection of 85% — a figure which would have been higher if it were not for a few difficulties encountered early in the search.

Dr. Harold Edgerton was a great asset to the search, supplying both necessary technical expertise (he developed the side-scan sonar) and an unflagging curiosity and drive which inspired the entire group. Both he and Mr. Charles Miller, who also accompanied the search team aboard the USCGC CONIFER, are professors in electrical engineering at MIT, Boston, MA. Both men are very capable teachers of practical electronics and each cadet gleaned considerable knowledge, particularly from their trouble-shooting methods.

Setting up the search patterns was both an exercise in SAR procedures and in physical oceanography. After reviewing the reported positions of the BEAR's sinking, along with the history of local winds and currents in the area, the group decided to concentrate on six reported wrecks, three of which were deemed to have a high probability of being the BEAR. A parallel track search pattern centered on the first of these chartered wrecks was drawn up, the LORAN data was entered into the plotter, and the first of the searches commenced. As any veteran of such a mission knows, early hours of vigilance soon stretched into days of tedious steaming while everyone on board awaited the exclamation "We found it!" The ocean was not yet ready to divulge her secrets and the BEAR's sea-grave remained an enigma after five search patterns covering the first two reported wrecks.

The group then met in the CONIFER's wardroom to decide how to use the remainder of their nearly-exhausted on-scene time. It was a slim chance, but there seemed to be promise in the third most probable position — one heretofore unexplored since it was at a depth three times that of the other two. A quick search of this area produced no BEAR but the group believes that a more thorough search here (next year?) may produce the desired results.

Heading in to port, time was set aside for ƦOF Miller to demonstrate his underwater ɱera equipment to the cadets. This ex- ɛmely interesting exercise involved rigging a ɫevision/still camera unit from a ship's davit, ɲd controlling the cameras from surface ɱonitors. Black and white pictures of the sea ɫoor were taken with this unit, as were color ɩideo tapes.

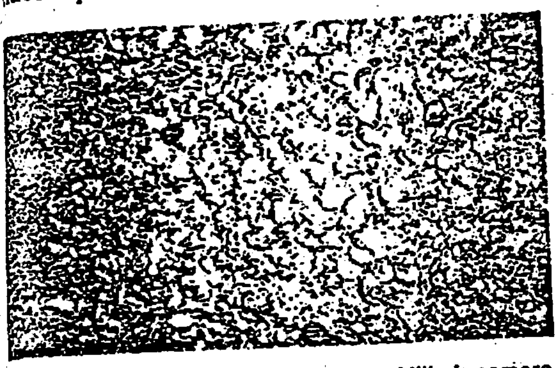


Photo of sea floor taken by Professor Miller's camera rig and strobe lights, depth about 300 feet.

Cadet 1/c Linda Johanson standing watch on the plotter.

From marlinspike seamanship to digital electronics, from SAR to precision navigation — the BEAR project encompassed a complete training package. Hopefully it will be tried again, and this time, building on the lessons of the first venture, BEAR will be found!

CADETS CONSTRUCTING OIL SPILL DRIFT MODEL

CAPT Ronald C. Kollmeyer, a '56 graduate of the Academy, is one of the Coast Guard's most talented oceanographers. He currently heads the Academy's Physical and Ocean Science Department.

CAPT Ronald C. Kollmeyer, acting head of the Department of Physical and Ocean Science, has announced that his Department, in concert with the Computer Center and with aid and advice from the Coast Guard Oceanographic Unit and Research and Development Center, is embarking on a major project — that of producing an Oil Spill Drift Computer Model for Long Island Sound. Many cadets will participate in its implementation.

The need for this project can be seen when you realize that over 32 million tons of commerce are off loaded in Long Island Sound ports each year and 90% of that volume consists of refined petroleum products.

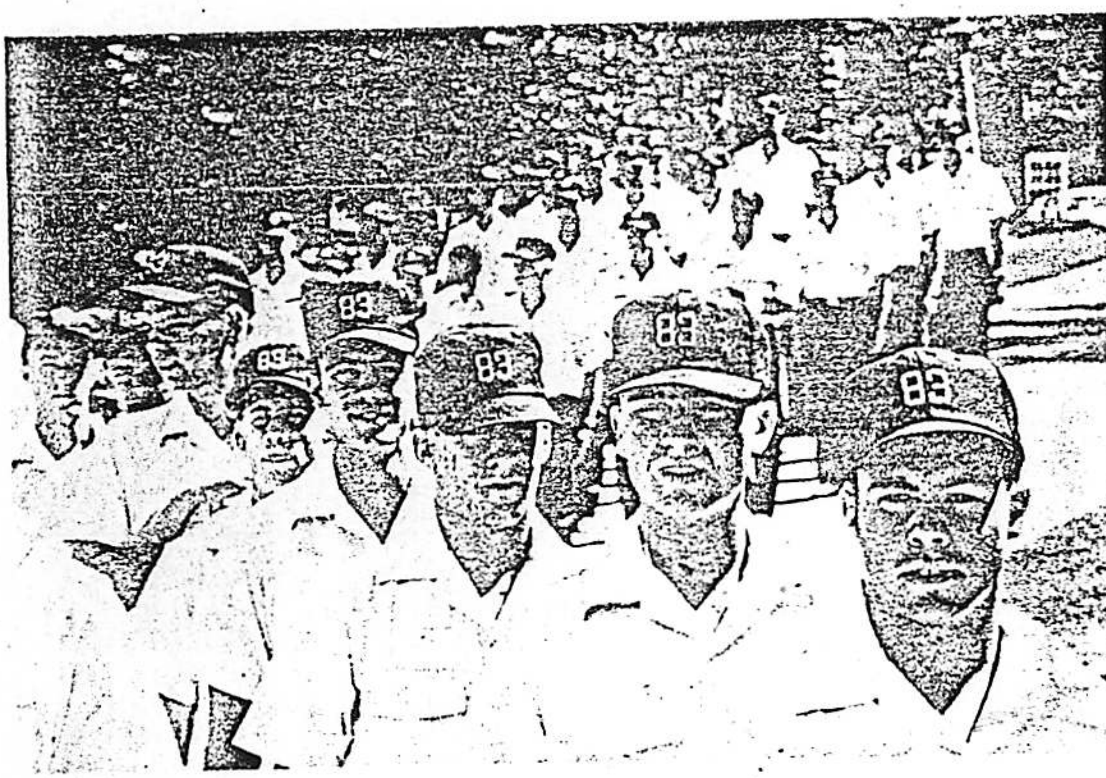
The two major uses for an oil spill drift prediction model are: (1) to facilitate the clean-up of oil spills by allowing the clean-up crews to anticipate where the oil will be going, and (2) to trace the origin of a spill to prevent further damage and, if necessary, identify the spiller for legal action.

Establishing this model provides a major challenge because of the size of the region, the number of ports and the high volume of traffic. The model will, upon command, produce a time series of charts for a given time period displaying the expected location, shape and concentration of an oil spill within the Long Island Sound.

U.S. COAST GUARD
ACADEMY
PARENTS NEWSLETTER

DEPARTMENT OF TRANSPORTATION • UNITED STATES COAST GUARD

CLASS OF '83 OFF AND RUNNING!



"Having been appointed to the grade of Cadet in the United States Coast Guard, do you solemnly swear that you will support and defend the Constitution of the United States against all enemies, foreign and domestic; that you will bear a true faith and allegiance to the same; that you will well and faithfully discharge the duties of the office of which you are about to enter, so help you God."

With a resounding "I DO" echoing throughout Washington Parade 300 young men and women became, officially, the CGA Class of '83.

In his Swearing In Ceremony remarks, Assistant Superintendent CAPT Jim Kelly — pinch hitting for the SUPT who was absent on other duty — called to mind his own first day as a cadet 31 years ago. After a day of beginning a new lifestyle with new clothing, a new haircut, new discipline, and violent physical activity,

NEW LONDON, CONNECTICUT SUMMER 1979