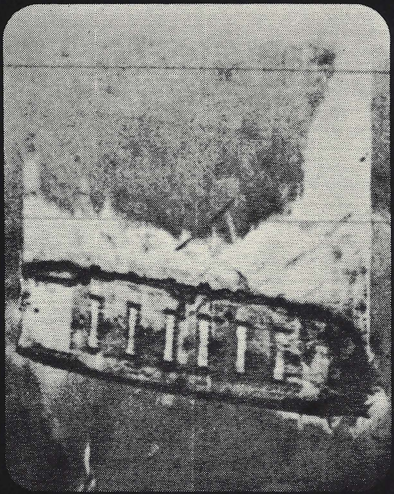
Lighthouse

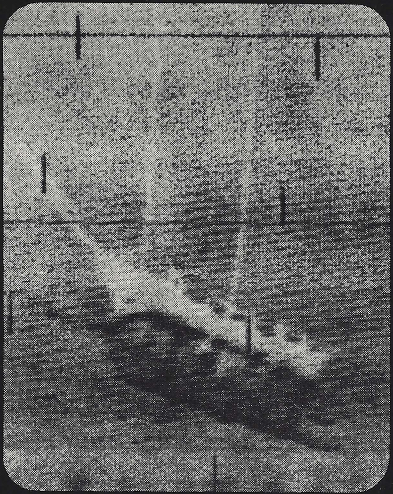
JOURNAL OF THE CANADIAN HYDROGRAPHERS' ASSOCIATION

Edition No. 22, November, 1980

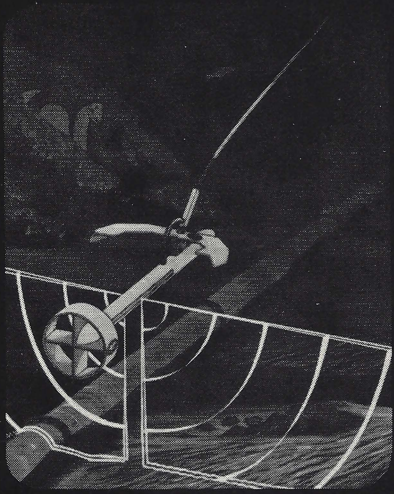
LOOKING FOR SHIPWRECKS...?



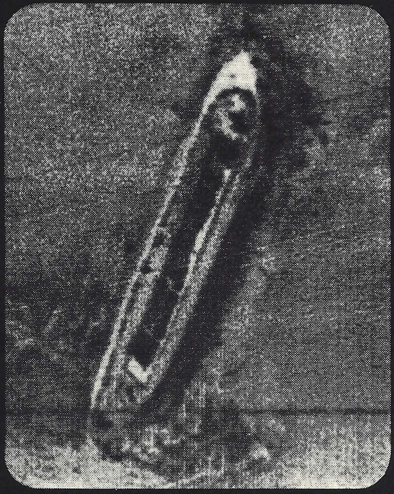
Klein HYDROSCAN Side Scan Sonar Record of an Old Wooden Sailing Barge in the Great Lakes.



American Schooner Hamilton which sank in Lake Ontario in the war of 1812 [Courtesy Royal Ontario Museum and Canada Centre for Inland Waters].



Klein HYDROSCAN Side Scan Sonar Record of the Ironclad U.S.S. Monitor [Courtesy of the Harbor Branch Foundation].



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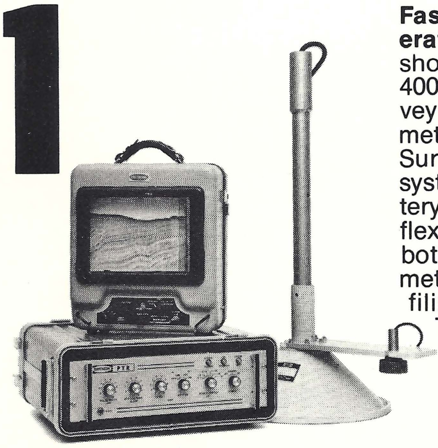

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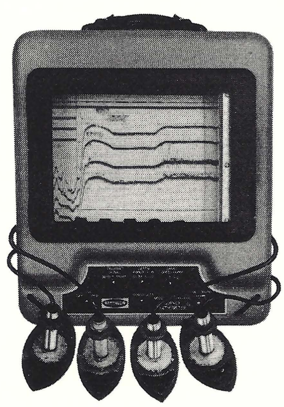

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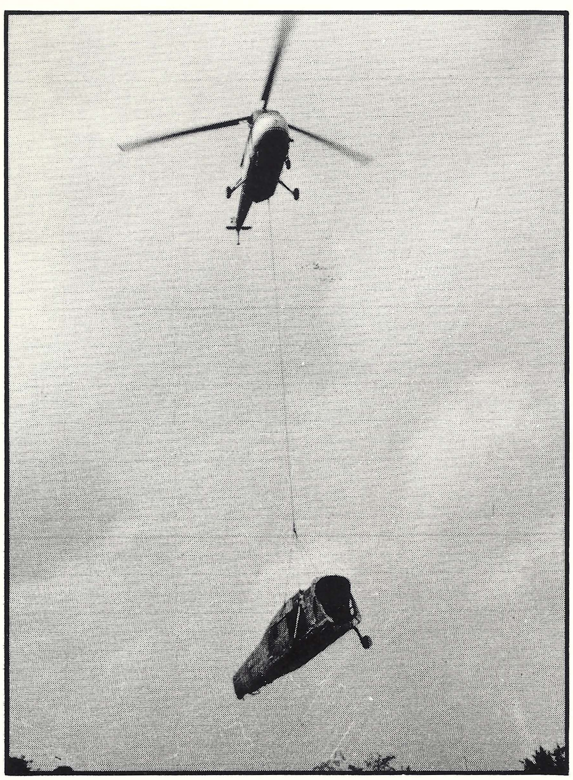

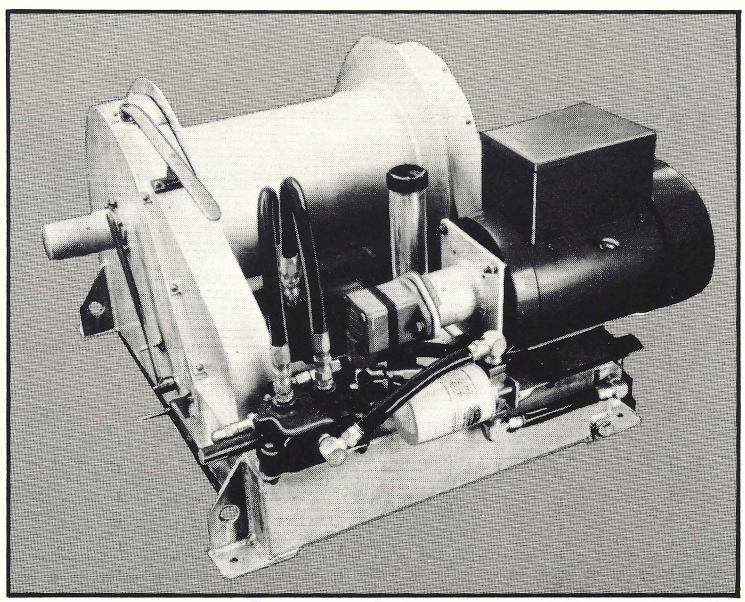

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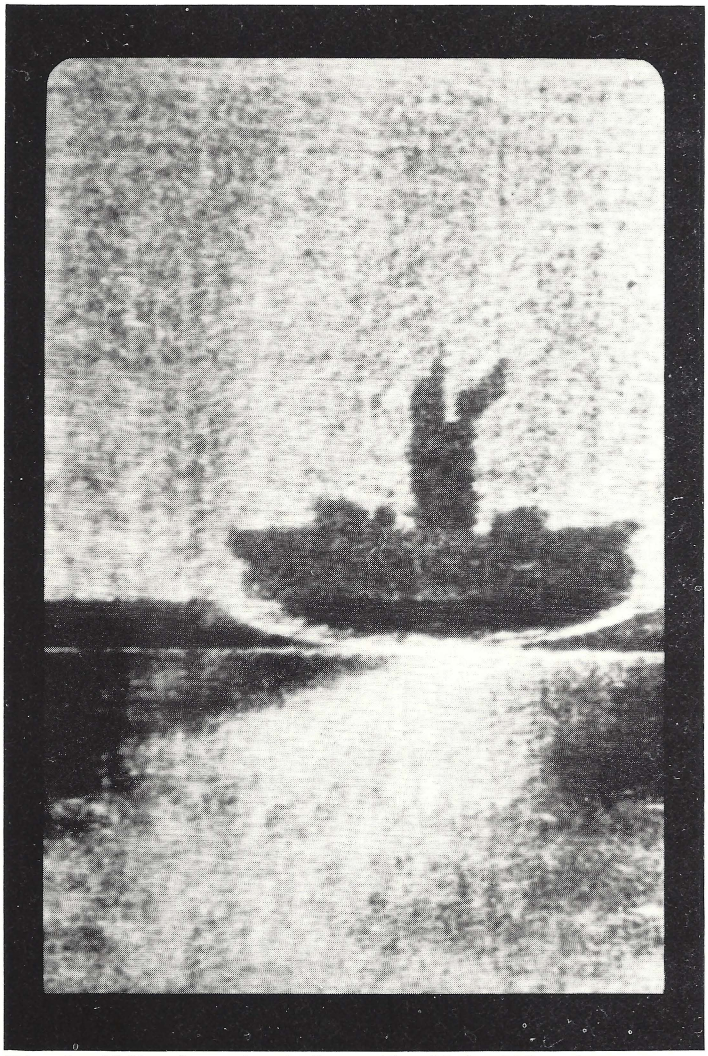

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Canadian Hydrographic Conference

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Sponsored by the
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and the
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Call for Papers

A total of fourteen (14) papers will be accepted for presentation at three morning sessions. Topics are expected to range from the practical to the theoretical aspects of hydrographic surveying and charting, and their related fields. Authors wishing to present a paper should submit an abstract, complete with a short biographical note, to the conference chairman no later than December 15th, 1980.

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EDITION No. 22 **LIGHTHOUSE** NOVEMBER, 1980

JOURNAL OF THE CANADIAN HYDROGRAPHERS ASSOCIATION

LIGHTHOUSE is published twice yearly by the Canadian Hydrographers Association and is distributed free to its members. Subscription rates to non-members are $3.00 per single issue or $6.00 yearly.

All correspondence should be sent to the Editor, **LIGHTHOUSE,** c/o Canadian Hydrographers Association, 867 Lakeshore Rd., P.O. Box 5050, Burlington, Ontario L7R 4A6.

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A Message from the President

The past three years as National President have been interesting ones for me. I have enjoyed the challenges and the rewards, but even more I have enjoyed the help and support of all the members.

Since my term is nearing its end, I want to take this opportunity to thank you all for making my task a rewarding one. A lot has happened over the years. We have sponsored international conferences and symposia. We are affiliated with C.I.S. through the Hydrographic Committee. LIGHTHOUSE has achieved worldwide circulation. We have a lot to be proud of, but we should always be looking for ways to advance our profession through the Association.

Elections for the next National President take place in December. Candidates are nominated and elected by the National Executive and the new president begins his term the week of the Canadian Hydrographic Conference. You may want to put names before your branch executive for their consideration.

George Macdonald

Sounding Selection from a Digital Data Base

G.D. Macdonald

Central Region
Canadian Hydrographic Service
Burlington, Ontario

Prologue

Ever since the first digital sounding was recorded on board a survey vessel, the Canadian hydrographer has been writing and modifying computer programs to do what is done so well by hand: select soundings for the field sheet.

The recommendations made in this paper are not revolutionary, but it is high time we developed a national concensus concerning computer-assisted depth selection and digital data archiving.

Introduction

Hydrographers have been collecting soundings and displaying them in graphic form on charts and field documents for centuries. It was easy to select the depths to be plotted, since virtually every sounding collected by leadline could be used. When echo sounders were first used in 1929 by the Canadian Hydrographic Service, it became necessary to devise methods of choosing significant depths from the analog record (echogram) to best represent the sea floor. The spacing scale and multiple divider became indispensable, and the circle sounding found a place in our hearts. Changes in surveying and data processing techniques evolved with time until they became second nature to an experienced hydrographer.

Electronic positioning systems began to slowly replace sextants in the 1960's, and survey data that had always been collected and processed by hand were soon available in a form that a computer could understand. When Canadian hydrographers were introduced to portable computers in the late 1960's it looked like digital data collection and computer-assisted depth selection were the answers to a prayer. After thirteen years of toil and sweat and a lot of trial and error, there are still some basic questions being asked.

How should the critical soundings be selected from source data to best represent the bottom? What disciplines inside or outside the Canadian Hydrographic Service will use the digital sounding data set and how will it be used? What data should be archived in digital form?

Selecting Depths

In Canada, the document containing the selected soundings, shoreline, contours and other data collected in the field at survey scale, is called the field sheet. After spending an entire career selecting depths and constructing field sheets by hand, it appears to be an easy task to emulate the method in a computer program. But there are a number of ways to decide which points stay and which ones go. The simplest algorithm might base the decision on the distance between selected points. How far have we travelled? Is there room to plot another depth keeping in mind survey scale and number size? This would produce a neat sheet, but obviously the deeps and shallows that would interest a chart user could be overlooked. If the bottom was free of anomalies it would be a reasonable solution, but this is seldom the case. A time-based selection algorithm would have the added problem of vessel speed not remaining constant, causing some soundings to overplot (plot on top of one another). Distance and time could become useful parameters in more sophisticated algorithms.

A statistician might consider averaging a given number of depths and positions, and plotting the average, but the resulting marine disaster could be embarrassing.

The important depths are shallows and deeps, with shallow depths being most critical to shipping interests. So the computer could be programmed to consider a set number of points, pick the shallow and plot it. The process would be repeated on the next set of points. If all the shallow points were plotted with their true positions, overplot could result in an illegible document; if they were plotted with their average positions to reduce overplot, the bottom representation would be distorted.

Another way to select points would be to keep all the critical deeps and shallows within a defined set of criteria. These points would closely resemble the bottom profile but other problems could arise. In areas where the bottom is rough, too many points would be selected to plot legibly at survey scale. In flat areas only a few points would be chosen, leaving large gaps in the sounding document. By using this method, points would be selected to best represent the bottom independent of survey scale. The methods previously described use survey scale to define how often a point is selected.

None of these methods by themselves are satisfactory, but by combining some of their features an algorithm could be defined that would suit our needs. For instance, if we selected the critical deeps and shallows, but also checked the distance between selected points to see if they plot on top of each other, and if they do then select the most critical depth for plotting, we would be getting closer to our requirement.

Since each region of the Canadian Hydrographic Service has its own survey requirements and peculiarities, approaches to common problems may vary slightly from region to region. The selection algorithm used most by Canadian hydrographers was developed in Atlantic Region during the late 1960's, and is still being used in one form or another by each of the regions today. In its original form it was record dependent. This means that no matter how many data points are contained in one record, the same number of points will be selected from each record, including the shallowest, the deep on either side of the shallow, and a gap filler (usually the mid-point). To make a good sounding selection, the length of each record must be based on survey scale and launch speed. This approach is used in Atlantic and Central Regions today. Changing the record length in the processing software to match survey scale and vessel speed is simple and effective. The algorithm also checks the distance between soundings to ensure that the most critical soundings are selected for plotting, while the field sheet remains legible. The Pacific Region reports that their selection routine is essentially record independent, but the same basic algorithm is being used.

One method that is often discussed but has never been tried is to select contour intervals instead of depths, along with the most critical deeps and shallows. This scheme would present similar problems to the methods previously described, such as overplot or large gaps in the selected data.

Using Selected Depths

Before we can determine how the critical soundings should be selected, we must decide who will use the data, both in digital and graphic form, and how the data will be used.

Right now the biggest users of digital data are hydrographers. From data recorded on-line or produced off-line in the field, they draw field sheets. The data, now in field sheet form, are used by a number of disciplines.

Cartographers, working for the Canadian Hydrographic Service, produce nautical charts from our field sheets, mainly to provide safe navigation for shipping. A cartographer would tell you that the field sheet provides him with too much depth information. In a digital form, the data are difficult to use because of the difference between chart scale and survey scale. He would prefer a reduced data set, at chart scale, in both digital and graphic form. It must be as accurate and detailed as a photographically reduced field sheet, but not as cluttered.

The Geoscience Mapping Section of the Canadian Hydrographic Service in Ottawa regularly use hydrographic field sheets. They have an opposing view to that of the cartographer. Their needs cannot be satisfied by simply supplying, in graphic or digital form, the sounding data depicted at survey scale on our field sheets. They are interested in all the anomalies that hydrographers may not be able to show at survey scale. The use of contours instead of soundings might allow us to show more detail on the field sheet. Or more points could be selected and stored than we show on the field sheet. The geoscience map-maker is presently going back to the echogram, sounding notes and boatboard for this additional information.

Other potential users, such as oil companies and other marine interests in government or private industry, need as much data as we can provide, normally more than we are geared to collect on a regular hydrographic survey. They too, are likely to revert to the echogram for some of the additional bottom detail required. When this falls short of their needs they perform their own hydrographic surveys.

Is there a happy medium, then? The fact that we provide our main customer, the cartographer, with too much digital information might lead us to consider decreasing the amount of data stored in digital form. Some of us might want to increase the amount of data to satisfy the needs of others. Or we could consider producing three sets of data; one for the hydrographer and his field sheet, one for the cartographer and his chart and one for those who require more detail than the first two documents can provide.

Let us consider what we already have on hand.

The echogram, sounding notes and boatboard are archived. So regardless of what data are recorded, processed or archived in digital form, any customer can derive whatever information is required from the original survey documents, within the constraints of scale, line spacing, positional accuracy and so on. It should be noted that it is nearly always impossible to achieve a higher accuracy than that inferred by survey scale ($\pm$ 1 mm at scale).

The digital data set, collected and processed during the survey, is also archived in one form or another. The data may or may not have passed through hardware or software filters to reduce the amount of bad data, but it is a safe bet that there is still an abundance of garbage on record. Positions and depths could contain errors, and the amount of bad data could depend on a number of variables; type of positioning system, range, bottom type, depth, weather, speed of vessel, condition of hardware, sophistication of software and so on. Obviously, to hand this data set over to other agencies in its raw condition is ludicrous. The data would be useless without the echogram and sounding notes, and perhaps not a lot more use with them. To edit the data set and then pass it on would be a difficult task. Some software data massaging would be useful and most errors (especially the large ones) could be eliminated. The latest generation of data loggers have built-in software to filter data on-line. This has reduced the number of recorded errors. The next generation of depth digitizing hardware could go a long way towards correcting a major source of errors.

The digital data set recorded on-board the survey vessel, even though it contains errors, is the source for the hydrographic field sheet. Soundings are selected at survey scale using algorithms to produce, as closely as possible, a final product that resembles a hand-inked field sheet. The selected soundings are stored in digital form, and are edited as the next step of the processing phase. This is the only data set that the hydrographer can guarantee to contain no depth or positional errors.

In Atlantic Region the semi-automatic scaler is sometimes used to digitize depths off-line, that have been recorded in analog form on the echogram. This data set is more likely to be clean, barring human error, and can be merged with positions that have been digitized on or off-line.

The edited digital data set, whether selected with a computer software package or with some manual assistance, makes up the digital field sheet. Before the final field sheet is plotted, overplot that may be present from check lines or shoal examinations is eliminated, using the 'keep the shallow' philosophy.

The completed field sheet is passed on to the cartographer and the digital data base, containing only the soundings that appear on the field sheet, is archived. As we have pointed out, this is too much data for the cartographer to utilize in his chart-making process, and too little data for other disciplines.

Do we need two additional sets of data?

A reduced data set for the cartographers' needs should not be difficult to produce. This data set could be worked into the computer-assisted chart making process. Since cartographers are our main customers and are getting into the automation business, we should strive to supply this data set. It would be derived from an error-free data set (the field sheet) so would require a minimum of editing. Some details need to be worked out. Reducing the data set while retaining contour accuracy and field sheet detail is not just a simple matter of removing overplot.

A larger data set for other governmental and private concerns is another matter. This digital data set already exists, remember, as the field sheet source data. But it is full of errors and would be difficult for another agency to use. The significant points (within defined limits) could be selected to represent the bottom profile. This would also contain a great number of errors, and would require a lot of editing. As digital data become more reliable the impact of the editing task would become less significant.

One alternative has not been tried but seems feasible. It would definitely increase the hydrographers' work load and may not provide enough data to satisfy the interested parties. The sounding selection process presently used by the Canadian Hydrographic Service picks deeps as well as shallows. These deeps, and in fact some shallows, are not always plotted because there is no room at survey scale. If two soundings overplot, the bias is always towards the shallow. Only those soundings that are plotted are stored in digital form. But there is no reason to exclude the unplotted deeps and shallows from the digital data base, except that it will increase the amount of editing required. While doubling the editing task it could still leave the user running for the echogram to see what the bottom really looks like.

Conclusions

To keep the sounding selection program as simple as possible, and easy for hydrographers to use and understand, it should be working with clean digital source data. This means that before any depths are selected, the data recorded on the logger will need to be verified and changes or deletions made as necessary. This is not a trivial concern and should, perhaps, be the focus of our attention for the next little while.

The best place for quality control is at the source, and there has been some work done in this area already. The depth and position filters in the NAVBOX (a micro-processor based data logger) have helped to reduce the amount of bad survey data. Better depth digitizers and improved software filtering techniques could greatly improve the reliability of recorded data and it could become possible to accurately forecast data through short periods of no data.

This may be incorporated in the next generation logging system but for the time being problems with bad data still exist. For instance, if a bad depth is selected as a critical data point (the recorded incorrect value is shallower than the rest), this will cause other selection errors to be made. The preceding and following depths would be selected or discarded for the wrong reason. It would be a definite advantage to eliminate the bad depths from the digital source data before making a sounding selection. Bad positions would have a similar effect on data selection.

Interactive editing techniques could use up a lot of the hydrographers' time and patience (something we are not all blessed with an abundance of). Still, the echogram could be reproduced from digital source data on a graphics display terminal, scanned for errors, and corrected. Positions could be edited in the same manner. New positions to replace bad data could be interpolated, either linearly or quadratically. The program could also apply calibration corrections to depths and positions. Depths would be selected from this clean data set.

For the field sheet, sounding selection from clean source data would be straightforward, implementing the selection algorithm presently used in the regions. The clean source data could also be used reliably by other government and private concerns, to meet their particular needs. I am sure this data set will still be used side by side with the echogram.

This leaves the cartographer still looking for a useable digital data base. Here we could take a number of approaches. The cartographer could ignore the digital data, as he is doing now, and concentrate on the graphic representation. Or we could offer the cartographer a reduced data set that could fit directly into his automated data processing scheme. One way to accomplish this would be to plot the field sheet data at chart scale with the overplot removed. This would eliminate some of the detail but, together with a contour package, would probably provide an accurate data base close to the needs of the cartographer. A third alternative would be to let the cartographer reduce the field sheet data set as part of the computer-assisted chart-making process. In any case, the digital data collected by the hydrographer should have some place in the chart-making scheme.

As a minimum requirement, the digital field sheet data base is being archived in each of the regions. Some digital source data, full of errors, has also been archived in Central and Pacific Regions. In addition, the Pacific Region has archived some of the data from intermediate processing steps.

Recommendations

Our first priority is quality control. During data acquisition, or as the first processing step, a clean digital data source should be produced. It means developing hardware and software to accomplish the task, but would meet the requirements of other disciplines as well as hydrography.

The sounding selection algorithm presently in use throughout the Canadian Hydrographic Service appears to satisfy our needs and should continue to be used. Each selected sounding in this data set should be labelled with the time, day, year, launch, applied sounding reduction and survey scale (to imply positional accuracy). Present practise is to record only depth and position, but once the data are manipulated during an overplot removal process (where soundings are sorted) or a chart production process, the extra information becomes necessary to trace each sounding to its source. The selection program should eventually be rewritten to reflect changes in data reliability, in a simpler and easier to understand format.

The data archives for each field sheet should be comprised of 1. the echograms, sounding notes and boatboard, 2. the clean digital source data and 3. a digital version of the edited sounding selection, as it appears on the field sheet.

A digital cartographic base, derived from the digital hydrographic field sheet base should be produced and incorporated into the computer-assisted chart-making process. It should be at chart scale and accurately depict the detail recorded on the field sheet. It could be produced either as the final hydrographic processing step, or as the initial cartographic chart production task. This would not negate the need for a digital field sheet, since the survey could cover a number of charts at different scales, and chart limits or scales can change.

As the rules outlined in Hydrographic Standing Orders governing the production of field sheets are modified, other methods of selecting significant data points could be considered. A contour selection instead of a depth selection could be made, for instance, as new chart formats evolve. The need for a formal graphic document such as the field sheet may be questioned once the digital data are complete, dependable and part of the chart-making process.

Finally, if we ever solve all the problems of quality control and depth selection that are presently competing for time on our busy schedule, we are still a long way from producing a complete digital document. The problems involved in representing the remaining field sheet information (aids, contours, bottom samples, shoreline and so on) in digital form will soon need to be addressed, and possible solutions should not be far from our minds as we continue our search for new and exotic avenues to explore.

Probability Study of Pingo-Like Features in the Beaufort Sea

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This report was prepared for the Canadian Hydrographic Service, Pacific Region under a contract let to Barrodale Computing Services Ltd., Victoria, B.C.

INTRODUCTION

The main purposes of this probability study are to estimate the number of Pingo-Like-Features (PLF's) in a certain area of the Beaufort Sea, to establish zones of constant average PLF density, and to determine the optimal sampling method for future experiments. The findings of this report are based on sampling data provided from analysis of continuous depth profiles taken throughout the area of interest.

There is strong statistical evidence to support the hypothesis that it is virtually impossible to detect a PLF smaller than 75 meters in diameter using the given sampling equipment and procedures. This hypothesis has been adopted here. Hence, no inferences can be made with regard to PLF's in the under 75m. diameter category.

The main area of concern affecting reliability of estimates pertains to the sizes of detected PLF's. Accurate measurements of PLF diameters were *not* provided. Enough date to permit reasonable diameter approximations were available for only 63% of the PLF's. It was necessary to estimate the remaining 37% from incomplete data. The accuracy of the latter estimates is questionable.

THE PROBABILITY MODEL

A given area R of the Beaufort Sea (see Maps 1 and 2) contains an unknown number N of PLF's randomly scattered throughout R in unknown locations. Average PLF density is not constant over R but varies from one zone to another. The PLF's are mound shaped of various sizes and are assumed to have circular bases the diameters of which are unknown.

The area R is partitioned into k regions. For $1 \le j \le k$, the j-th region is sampled using continuous depth profiles along paralled lines spaced ℓ_j meters apart. All regions are shown on Map 1 labelled with their ℓ-values.

It is assumed that a given PLF will be detected if and only if the nearest sounding line intersects its perimeter with a chord of length greater than or equal to c meters. The constant c is assumed to be known; its designation will be dicussed in a later section of this report.

Let n_j denote the (unknown) number of PLF's positioned in region j, $1 \le j \le k$. (Note that $n_1 + n_2 + \ldots + n_k = N$.) For $1 \le i \le n_j$ and $1 \le j \le k$, let x_{ij} denote the perpendicular distance from the centre of the i-th PLF in the j-th region (i.e. the ij-th PLF) to the nearest sounding line in the j-th region. It is reasonable to assume that the x_{ij}'s are independently distributed random variables such that each x_{ij} is uniformly distributed on the interval $(0, \ell_j/2)$. Denote the (unknown) diameter of the ij-th PLF by d_{ij}.

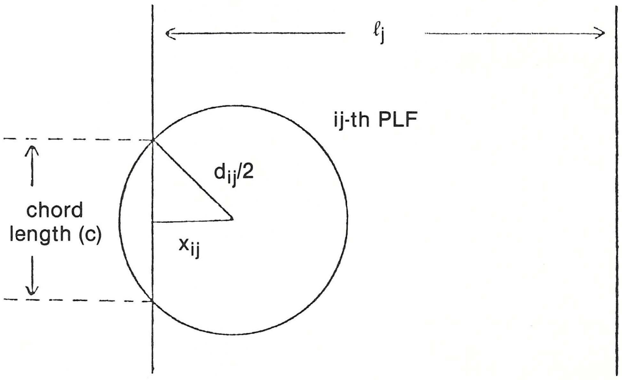


Figure 1

The chord length in Figure 1 must be greater than or equal to c meters in order that the ij-th PLF will be detected. This will happen if and only if

$$0 \le x_{ij} \le \sqrt{(d_{ij}/2)^2 - (c/2)^2}.$$

Therefore,

$$P(\text{ij-th PLF will be detected}) = \frac{\sqrt{(d_{ij}/2)^2 - (c/2)^2}}{\ell_j/2}$$

$$= \begin{cases} \sqrt{d^2_{ij} - c^2}\,/\,\ell_j, & \text{if} \sqrt{d^2_{ij} - c^2} < \ell_j \\ 1, & \text{if} \sqrt{d^2_{ij} - c^2} \ge \ell_j. \end{cases}$$

These probabilities are listed in Tables 3.1 through 3.4 for c = 25(25)100m., d = 100(50)1550m., ℓ = 50(50)1500m.

With the given sampling equipment, operational procedures, and measurement techniques, it would be unreasonable to expect PLF diameter measurement accuracy better than ±25 meters. Therefore, without sacrificing reliability, diameter measurements have been rounded to the nearest 50 meters permitting use of the binomial distribution to estimate the number of PLF's.

For a given subarea S, let

N_S = Total number of PLF's located in subarea S,

$N_S(d,\ell)$ = Total number of PLF's having diameter = d meters that are located in a section of S where sounding lines are spaced ℓ meters apart,

$$p(d,\ell) = \begin{cases} \sqrt{d^2 - c^2}/\ell \text{ if } \sqrt{d^2 - c^2} < \ell \\ 1 \quad \text{if } \sqrt{d^2 - c^2} \geq \ell, \end{cases}$$

$T_S(d,\ell)$ = Total number of PLF's having diameter = d meters that are detected in a section of S where sounding lines are spaced ℓ meters apart.

Then the random variable $T_S(d,\ell)$ has a binomial distribution with parameters $N_S(d,\ell)$ and $p(d,\ell)$. This is an interesting and unusual application of the binomial distribution. Here the number $N_S(d,\ell)$ of independent Bernoulli trials is the unknown parameter, while the probability of success $p(d,\ell)$ is known; the reverse is the case in almost all applications. The natural estimator for $N_S(d,\ell)$ is $T_S(d,\ell)/p(d,\ell)$. This estimator is unbiased and has variance

$N_S(d,\ell)\{1 - p(d,\ell)\}/p(d,\ell)$

(hence, the standard error is

$$\sqrt{T_S(d,\ell)\{1 - p(d,\ell)\}/\{p(d,\ell)\}^2}\ ).$$

The estimator for N_S is

$$\hat{N}_S = \sum_d \sum_\ell T_S(d,\ell)/p(d,\ell),$$

with standard error

$$\sqrt{\sum_d \sum_\ell T_S(d,\ell)\{1 - p(d,\ell)\}/\{p(d,\ell)\}^2}$$

Numerical estimates of N_S and their standard errors are listed in Table 5 for S = Zone A, Zone B, Zone C, Zone D, Zone E, Zone F, Zone Z, and Area R. All zones are shown on Map 2.

The estimator for the number N(d) of PLF's in Area R that have diameter = d meters is

$$\hat{N}(d) = \sum_\ell T_R(d,\ell)/p(d,\ell)$$

with standard error

$$\sqrt{\sum_\ell T_R(d,\ell)\{1 - p(d,\ell)\}/\{p(d,\ell)\}^2}$$

Numerical estimates of N(d) and their standard errors are listed in Table 4 for d = 100(50)2100m.

THE CONSTANT c

The results of this report are based on the assumption that c = 75 meters. That is, it is assumed that a PLF will be detected if and only if the sounding line nearest the centre of the PLF intersects its perimeter with a chord length (apparent diameter) greater than or equal to 75 meters.

There is substantial evidence to support the validity of this assumption. Of the 190 PLF's found, 10 were detected with apparent diameters equal to 100 meters. None were detected with apparent diameters less than 100 meters. Since the apparent diameter figures were rounded to the nearest 50 meters (184 of the 190 apparent diameters recorded are divisible by 50 meters), and since the lower limit c is likely to be approached very closely in at least one of the 190 trials, it is reasonable to specify c = 75 meters. If the correct value of c were 50 meters, there would have been an 84% chance of detecting at least one of the 190 PLF's with an apparent diameter less than 75 meters. Since this event did not occur it would be unreasonable to set c as low as 50 meters.

If, in future sampling, different equipment and/or operating procedures were to be used the constant c would have to be adjusted accordingly.

Tables 3.1, 3.2, 3.3, 3.4, provide PLF detection probabilities for c = 25, 50, 75, 100 meters, respectively.

DISTANCES BETWEEN SOUNDING LINES

Map 1 shows Area R partitioned into many regions such that within each region it is reasonable to assume that the sounding lines are parallel lines spaced a constant distance ℓ meters apart. The ℓ-value associated with each region is clearly marked on the map.

PLF DIAMETER CALCULATIONS

PLF diameters were calculated using two different techniques depending on the amount of data available. The 119 PLF's listed in Table 1.1 were examined in sufficient detail to permit accurate approximations of their true diameters. For these PLF's diameters were calculated using the formula

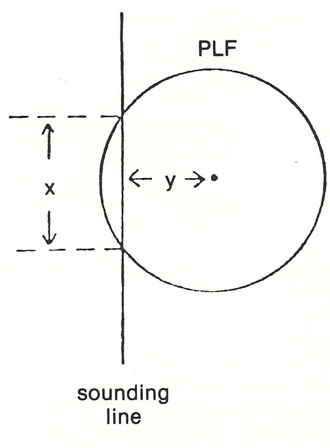
$$d = 2\sqrt{y^2 + (x/2)^2},$$

where

x = apparent diameter (chord length)

and

y = perpendicular distance from sounding line to PLF centre.



A list of the 119 diameters rounded to the nearest 50 meters is given in Table 1.1.

The remaining 71 PLF's are listed in Table 1.2. For 68 of these, only the apparent diameter values (x-values) were available. Since the average perpendicular distance y from sounding line to PLF centre was 150 meters for the 119 PLF's listed in Table 1.1, the formula

$$d = 2\sqrt{(150)^2 + (x/2)^2}$$

was used to calculate the diameters given in Table 1.2, except for PLF numbers 1, 44, and 74. These three PLF's were given diameters equal to the average diameter among those having similar heights, because both their x and y-values were missing.

CONFIDENCE INTERVALS FOR THE NUMBER OF PLF's

Approximate 100(1-α)% confidence intervals for the number of PLF's in the various diameter categories can be constructed using the data in Table 4 as follows. The true number is within the limits:

$$\text{(estimated number)} \pm (z_{1-\alpha/2})\text{(standard error)}$$

with approximately 100(1-α)% confidence, where $z_{1-\alpha/2}$ is the (1-α/2)th quantile of the standard normal distribution. Some specific values of $z_{1-\alpha/2}$ are listed below.

$1-\alpha$	$z_{1-\alpha/2}$
.90	1.65
.95	1.96
.99	2.58

For example, with approximately 95% confidence the true number of PLF's in Area R that fall into the 600m. diameter category is within the limits:

11.97 ± (1.96)(1.08) (i.e. between 10 and 14 inclusive).

Applying the same general formula, the data in Table 5 can be used to construct 100(1-α)% confidence intervals for the number of PLF's in the various zones. For example, Zone Z contains 48 ± (1.96)(5.00) (i.e. between 38 and 58 inclusive) PLF's with approximately 95% confidence. The combined Area R contains 300 ± 64 PLF's with approximately 95% confidence.

ZONES OF CONSTANT AVERAGE PLF DENSITY

Construction of zones of approximately constant average PLF density was accomplished in two stages. Initial estimates were made on the basis of visual analysis of a map of Area R that contained only the pattern of 190 dots indicating the locations of all detected PLF's. To avoid visual distortions no other identifying marks, such as I.D. numbers and connecting lines, were made on this map. Also, careful consideration was given to the fact that distortions were caused by varying the distance ℓ between sounding lines. From this initial phase nine zones were tentatively created. Then estimates with associated standard errors were obtained for the true number of PLF's in each zone. Also, within each zone PLF density measured in PLF's per 100 sq. km. was estimated. By combining initial phase zones having nearly equal PLF density estimates, the number of different zones was reduced from nine to six. Map 2 shows these six zones labelled A, B, C, D, E, F. Estimates of PLF density with associated standard errors are listed in Table 5.

Also shown on Map 2 and listed in Table 5 is the special Zone Z, a square region 256 sq. km. in size, that has been selected by the Institute of Ocean Sciences for intensive further study.

FUTURE EXPERIMENTS

The Optimal Sampling Pattern

Using continuous depth profiles the optimal sampling pattern is parallel sounding lines spaced ℓ meters apart. The distance ℓ should be held constant throughout the sampled area. Then the probability of detecting a PLF with diameter d is

$$\sqrt{d^2 - c^2}\,/\,\ell, \quad \text{if } \sqrt{d^2 - c^2} < \ell.$$

Hence, ℓ can be set to attain the desired probability of capture for any size PLF. Detection probabilities for c = 75m. are listed in Table 3.3. For example, if it is desired to have a 90% chance of detecting a 500m. diameter PLF, sounding lines should be spaced 550 meters apart.

The Search for Remaining PLF's in Area R

Suppose there are n PLF's in Area R having diameter ≥ d meters that remain undetected. Enumerate them and let $p_i(\ell)$ denote the probability of detecting the i-th one when sounding lines are spaced ℓ meters apart. Then

$$\prod_{i=1}^{n} p_i(\ell)$$

is the probability of finding all remaining PLF's in Area R having diameters ≥ d meters using sounding lines spaced ℓ meters apart. These probabilities are listed in Table 7 for d = 100 (50) 500 and ℓ = 50 (50) 500. They were computed using the data in Table 6 concerning the estimated number of PLF's that remain hidden in Area R.

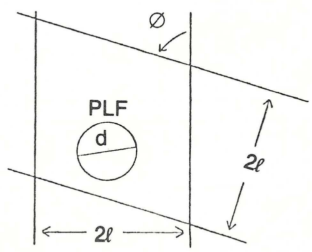
Parallel Search versus Crossing Search

Let p(d) denote the probability of detecting a PLF having diameter = d meters. If the area is searched using parallel sounding lines spaced ℓ meters apart, then

$$p(d) = \begin{cases} \sqrt{d^2 - c^2}\,/\,\ell & \text{if } \sqrt{d^2 - c^2} < \ell \\ 1 & \text{if } \sqrt{d^2 - c^2} \geq \ell \end{cases}$$

(See Section 2).

Alternatively, consider a crossing search pattern. Suppose the sounding lines are divided into two groups of parallel lines such that the lines within each group are spaced 2ℓ meters apart, and the two groups intersect at an angle $\varnothing$, where $0 < \varnothing < \pi$.



If $\sqrt{d^2 - c^2} \geq \ell$, the parallel search is clearly optimal because it is certain to capture the PLF. Consider the case where $\sqrt{d^2 - c^2} < \ell$.

For i = 1, 2, let G_i denote the event that the PLF will be detected by Group i. Then G_1 and G_2 are independent events and

$$
\begin{aligned}
p(d) &= P(G_1 \cup G_2) \\
&= P(G_1) + P(G_2) - P(G_1 \cap G_2) \\
&= P(G_1) + P(G_2) - P(G_1)P(G_2) \\
&= \frac{\sqrt{d^2 - c^2}}{2\ell} + \frac{\sqrt{d^2 - c^2}}{2\ell} - \left(\frac{\sqrt{d^2 - c^2}}{2\ell}\right)^2 \\
&= \frac{\sqrt{d^2 - c^2}}{\ell}\left\{1 - \frac{\sqrt{d^2 - c^2}}{4\ell}\right\} \\
&< \frac{\sqrt{d^2 - c^2}}{\ell}
\end{aligned}
$$

Therefore, crossing search is less efficient than parallel search. This result supports statements made above in "Optimal Sampling Pattern."

Data Needed For Future Probability Studies

If a new area were to be sampled from which a similar probability study were to be undertaken, the following sampling procedures should be strictly followed:

(a) Continuous depth profiles should be taken along parallel lines spaced ℓ meters apart.

(b) The distance ℓ should be held constant throughout the sampled area.

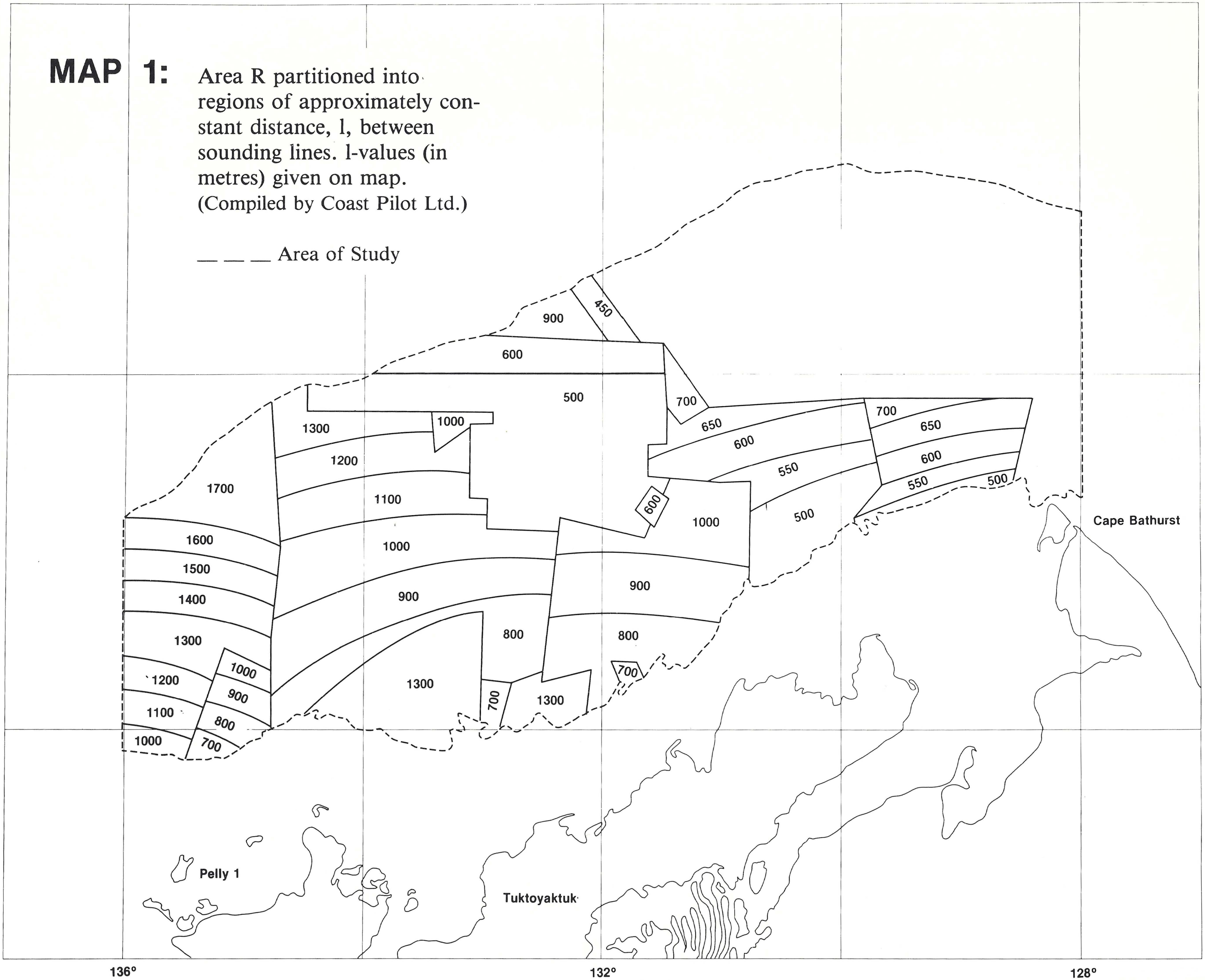
(c) The same sampling equipment, operating procedures and measurement techniques should be used for the entire sampling task.

(d) Each detected PLF should be examined in sufficient detail to obtain accurate measurements for apparent diameter, true diameter, and distance from PLF centre to sounding line.

(e) If during the examination of one PLF another feature is accidentally located that would not have been detected from *any* sounding line, it should be examined and recorded *separately* from those detected by sounding lines.

MAP 1: Area R partitioned into regions of approximately constant distance, l, between sounding lines. l-values (in metres) given on map. (Compiled by Coast Pilot Ltd.)

_ _ _ _ Area of Study



MAP 2: Area R partitioned into zones of approximately constant average PLF density. Zone Z superimposed. (Compiled by Coast Pilot Ltd.)

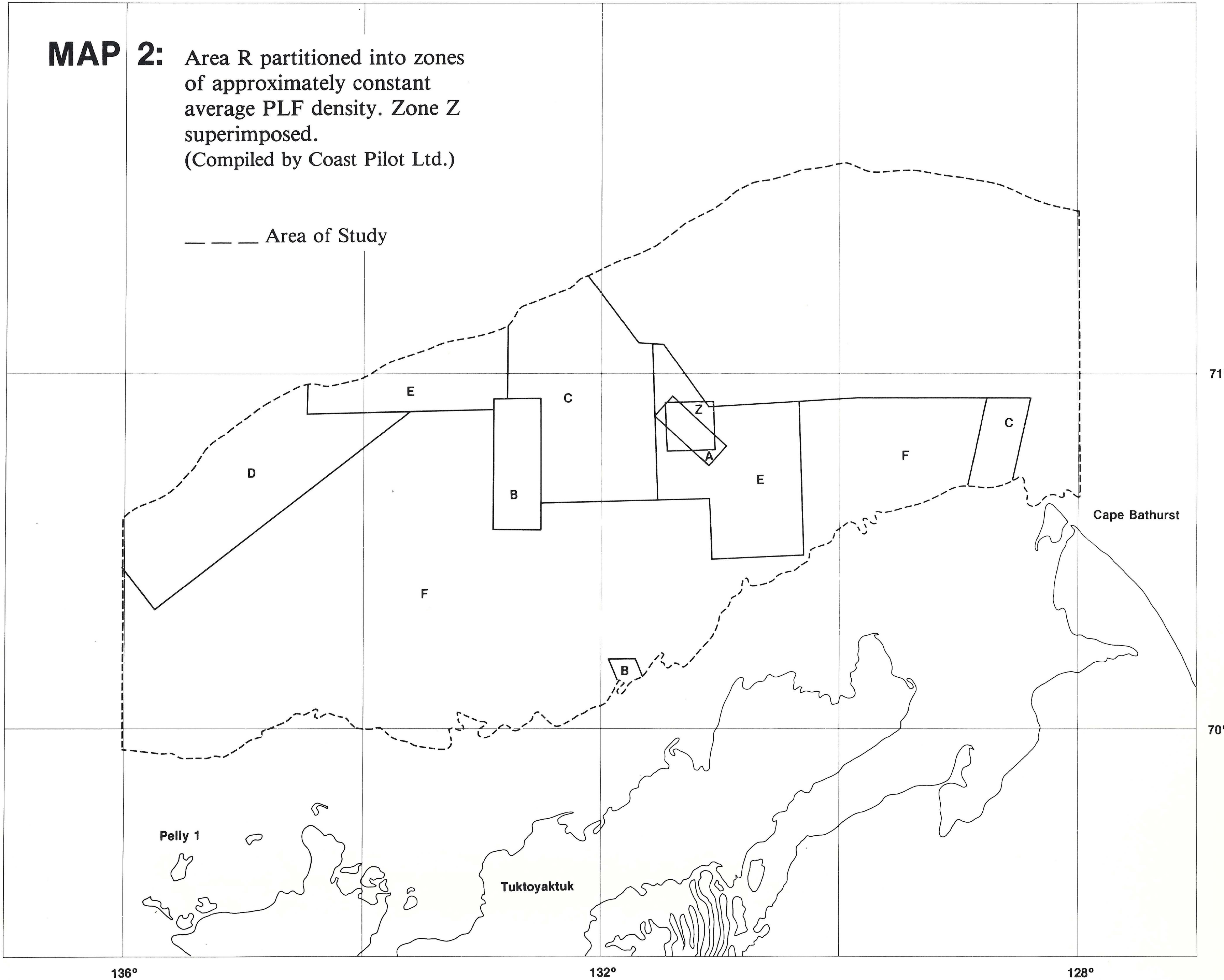


TABLE 1.1

PLF DIAMETERS

ID#	DIAMETER	ID#	DIAMETER	ID#	DIAMETER
4	750	71	650	136	350
5	500	72	500	137	450
6	1200	73	1850	138	550
10	350	75	500	139	550
11	550	76	200	140	850
13	1600	77	450	142	350
14	350	79	400	144	550
15	1900	80	800	145	550
16	800	81	700	147	850
17	900	82	400	149	650
18	650	83	400	150	600
20	400	84	550	151	600
21	700	90	250	152	500
22	400	94	550	153	750
23	950	96	500	156	550
24	1050	98	850	157	400
25	800	101	750	158	700
28	400	103	600	159	200
29	650	104	1100	167	850
31	350	107	400	169	600
32	550	108	500	170	400
37	650	109	900	171	1250
40	1250	111	650	172	550
43	450	113	500	174	600
46	800	114	700	175	500
47	1850	115	650	176	300
48	650	117	1500	177	400
49	950	119	1050	178	300
50	850	120	950	181	600
51	950	121	1050	182	400
53	1000	122	800	185	1300
54	150	123	650	186	1450
56	1100	125	900	193	400
59	600	126	900	194	800
60	100	127	1700	195	250
61	500	128	1800	201	1050
67	600	129	500	203	100
68	1500	132	300	204	350
69	1350	133	1000	205	600
70	450	134	1050		

TABLE 1.2

PLF DIAMETERS

ID#	DIAMETER	ID#	DIAMETER	ID#	DIAMETER
1	650	86	400	161	650
2	950	87	350	162	650
3	1050	88	450	163	800
7	1250	89	450	164	1050
8	900	92	1050	165	1550
9	900	93	1850	166	500
12	1050	95	650	173	500
19	800	99	1250	179	500
33	500	100	1350	180	450
34	500	106	1350	183	500
35	350	110	350	184	700
36	300	112	600	187	300
39	500	116	350	188	300
41	300	118	800	189	500
44	700	124	1600	190	300
52	500	130	500	191	350
57	450	135	350	192	600
62	1900	141	350	196	350
63	1000	143	400	197	350
64	300	146	350	198	350
65	350	148	1050	199	350
66	2100	154	500	200	450
74	650	155	350	202	400
85	400	160	650		

TABLE 2

NUMBER OF PLF's DETECTED FROM SAMPLING

d \ ℓ	450	500	550	600	650	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	Row Totals
100									1							1	2
150														1			1
200		2															2
250				1		1											2
300	3	2			2			1		1							9
350	2	10	1	5				1								1	20
400		3	1	4	5	2							1				16
450		4		2				1				1		1			9
500	2	8	2	2	3	1	1		1					1			21
550		6		1	2	1											10
600		5			3	2	1										11
650		7		3	1	2		1			1						15
700		4			1	1											6
750		2			1												3
800		3	1		1	3						1					9
850		3		1										1			5
900		5		1													6
950		1		1	1									2			5
1000		2												1			3
1050		4		1	2	1				1	1						10
1100		1													1		2
1150																	0
1200			1														1
1250		1	1		1						1						4
1300		1															1
1350		3															3
1400																	0
1450		1															1
1500		2															2
1550						1											1
1600					1			1									2
1650																	0
1700		1															1
1750																	0
1800		1															1
1850		1		1								1					3
1900				1	1												2
1950																	0
2000																	0
2050																	0
2100				1													1
														TOTAL			190

TABLE 3.1

PROBABILITY OF DETECTION IF c = 25m.

$$\text{Table Entry} = \begin{cases} \sqrt{d^2 - (25)^2} \big/ \ell & \text{if } \sqrt{d^2 - (25)^2} < \ell \\ 1 & \text{if } \sqrt{d^2 - (25)^2} \geq \ell \end{cases}$$

d \ ℓ	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500
50	.87	.43	.29	.22	.17	.14	.12	.11	.10	.09	.08	.07	.07	.06	.06	.05	.05	.05	.05	.04	.04	.04	.04	.04	.03	.03	.03	.03	.03	.03
100	1	.97	.65	.48	.39	.32	.28	.24	.22	.19	.18	.16	.15	.14	.13	.12	.11	.11	.10	.10	.09	.09	.08	.08	.08	.07	.07	.07	.07	.06
150	1	1	.99	.74	.59	.49	.42	.37	.33	.30	.27	.25	.23	.21	.20	.18	.17	.16	.16	.15	.14	.13	.13	.12	.12	.11	.11	.11	.10	.10
200	1	1	1	.99	.79	.66	.57	.50	.44	.40	.36	.33	.31	.28	.26	.25	.23	.22	.21	.20	.19	.18	.17	.17	.16	.15	.15	.14	.14	.13
250	1	1	1	1	.99	.83	.71	.62	.55	.50	.45	.41	.38	.36	.33	.31	.29	.28	.26	.25	.24	.23	.22	.21	.20	.19	.18	.18	.17	.17
300	1	1	1	1	1	1	.85	.75	.66	.60	.54	.50	.46	.43	.40	.37	.35	.33	.31	.30	.28	.27	.26	.25	.24	.23	.22	.21	.21	.20
350	1	1	1	1	1	1	1	.87	.78	.70	.63	.58	.54	.50	.47	.44	.41	.39	.37	.35	.33	.32	.30	.29	.28	.27	.26	.25	.24	.23
400	1	1	1	1	1	1	1	1	.89	.80	.73	.67	.61	.57	.53	.50	.47	.44	.42	.40	.38	.36	.35	.33	.32	.31	.30	.29	.28	.27
450	1	1	1	1	1	1	1	1	1	.90	.82	.75	.69	.64	.60	.56	.53	.50	.47	.45	.43	.41	.39	.37	.36	.35	.33	.32	.31	.30
500	1	1	1	1	1	1	1	1	1	1	.91	.83	.77	.71	.67	.62	.59	.55	.53	.50	.48	.45	.43	.42	.40	.38	.37	.36	.34	.33
550	1	1	1	1	1	1	1	1	1	1	1	.92	.85	.78	.73	.69	.65	.61	.58	.55	.52	.50	.48	.46	.44	.42	.41	.39	.38	.37
600	1	1	1	1	1	1	1	1	1	1	1	1	.92	.86	.80	.75	.71	.67	.63	.60	.57	.54	.52	.50	.48	.46	.44	.43	.41	.40
650	1	1	1	1	1	1	1	1	1	1	1	1	1	.93	.87	.81	.76	.72	.68	.65	.62	.59	.56	.54	.52	.50	.48	.46	.45	.43
700	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.93	.87	.82	.78	.74	.70	.67	.64	.61	.58	.56	.54	.52	.50	.48	.47
750	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.88	.83	.79	.75	.71	.68	.65	.62	.60	.58	.56	.54	.52	.50
800	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.89	.84	.80	.76	.73	.70	.67	.64	.62	.59	.57	.55	.53
850	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.89	.85	.81	.77	.74	.71	.68	.65	.63	.61	.59	.57
900	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.90	.86	.82	.78	.75	.72	.69	.67	.64	.62	.60
950	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.90	.86	.83	.79	.76	.73	.70	.68	.65	.63
1000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.87	.83	.80	.77	.74	.71	.69	.67
1050	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.87	.84	.81	.78	.75	.72	.70
1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.88	.85	.81	.79	.76	.73
1150	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.88	.85	.82	.79	.77
1200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.89	.86	.83	.80
1250	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.89	.86	.83
1300	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.90	.87
1350	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.90
1400	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.97	.93
1450	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.97
1500	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1550	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TABLE 3.2

PROBABILITY OF DETECTION IF c = 50m.

$$\text{Table Entry} = \begin{cases} \sqrt{d^2 - (50)^2} \Big/ \ell & \text{if } \sqrt{d^2 - (50)^2} < \ell \\ 1 & \text{if } \sqrt{d^2 - (50)^2} \geq \ell \end{cases}$$

d \ ℓ	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	1	.87	.58	.43	.35	.29	.25	.22	.19	.17	.16	.14	.13	.12	.12	.11	.10	.10	.09	.09	.08	.08	.08	.07	.07	.07	.06	.06	.06	.06
150	1	1	.94	.71	.57	.47	.40	.35	.31	.28	.26	.24	.22	.20	.19	.18	.17	.16	.15	.14	.13	.13	.12	.12	.11	.11	.10	.10	.10	.09
200	1	1	1	.97	.77	.65	.55	.48	.43	.39	.35	.32	.30	.28	.26	.24	.23	.22	.20	.19	.18	.18	.17	.16	.15	.15	.14	.14	.13	.13
250	1	1	1	1	.98	.82	.70	.61	.54	.49	.45	.41	.38	.35	.33	.31	.29	.27	.26	.24	.23	.22	.21	.20	.20	.19	.18	.17	.17	.16
300	1	1	1	1	1	.99	.85	.74	.66	.59	.54	.49	.46	.42	.39	.37	.35	.33	.31	.30	.28	.27	.26	.25	.24	.23	.22	.21	.20	.20
350	1	1	1	1	1	1	.99	.87	.77	.69	.63	.58	.53	.49	.46	.43	.41	.38	.36	.35	.33	.31	.30	.29	.28	.27	.26	.25	.24	.23
400	1	1	1	1	1	1	1	.99	.88	.79	.72	.66	.61	.57	.53	.50	.47	.44	.42	.40	.38	.36	.35	.33	.32	.31	.29	.28	.27	.26
450	1	1	1	1	1	1	1	1	.99	.89	.81	.75	.69	.64	.60	.56	.53	.50	.47	.45	.43	.41	.39	.37	.36	.34	.33	.32	.31	.30
500	1	1	1	1	1	1	1	1	1	.99	.90	.83	.77	.71	.66	.62	.59	.55	.52	.50	.47	.45	.43	.41	.40	.38	.37	.36	.34	.33
550	1	1	1	1	1	1	1	1	1	1	1	.91	.84	.78	.73	.68	.64	.61	.58	.55	.52	.50	.48	.46	.44	.42	.41	.39	.38	.38
600	1	1	1	1	1	1	1	1	1	1	1	1	.92	.85	.80	.75	.70	.66	.63	.60	.57	.54	.52	.50	.48	.46	.44	.43	.41	.40
650	1	1	1	1	1	1	1	1	1	1	1	1	1	.93	.86	.81	.76	.72	.68	.65	.62	.59	.56	.54	.52	.50	.48	.46	.45	.43
700	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.93	.87	.82	.78	.73	.70	.66	.63	.61	.58	.56	.54	.52	.50	.48	.47
750	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.88	.83	.79	.75	.71	.68	.65	.62	.60	.58	.55	.53	.52	.50
800	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.89	.84	.80	.76	.73	.69	.67	.64	.61	.59	.57	.55	.53
850	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.89	.85	.81	.77	.74	.71	.68	.65	.63	.61	.59	.57
900	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.90	.86	.82	.78	.75	.72	.69	.67	.64	.62	.60
950	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.90	.86	.82	.79	.76	.73	.70	.68	.65	.63
1000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.87	.83	.80	.77	.74	.71	.69	.67
1050	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.87	.84	.81	.78	.75	.72	.70
1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.88	.85	.81	.78	.76	.73
1150	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.88	.85	.82	.79	.77
1200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.89	.86	.83	.80
1250	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.89	.86	.83
1300	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.90	.87
1350	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.90
1400	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93
1450	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.97
1500	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1550	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TABLE 3.3

PROBABILITY OF DETECTION IF c = 75m.

$$\text{Table Entry} = \begin{cases} \sqrt{d^2 - (75)^2}/\ell & \text{if } \sqrt{d^2 - (75)^2} < \ell \\ 1 & \text{if } \sqrt{d^2 - (75)^2} \geq \ell \end{cases}$$

d \ ℓ	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500
100	1	.66	.44	.33	.26	.22	.19	.17	.15	.13	.12	.11	.10	.09	.09	.08	.08	.07	.07	.07	.06	.06	.06	.06	.05	.05	.05	.05	.05	.04
150	1	1	.87	.65	.52	.43	.37	.32	.29	.26	.24	.22	.20	.19	.17	.16	.15	.14	.14	.13	.12	.12	.11	.11	.10	.10	.10	.09	.09	.09
200	1	1	1	.93	.74	.62	.53	.46	.41	.37	.34	.31	.29	.26	.25	.23	.22	.21	.20	.19	.18	.17	.16	.15	.15	.14	.14	.13	.13	.12
250	1	1	1	1	.95	.79	.68	.60	.53	.48	.43	.40	.37	.34	.32	.30	.28	.26	.25	.24	.23	.22	.21	.20	.19	.18	.18	.17	.16	.16
300	1	1	1	1	1	.97	.83	.73	.65	.58	.53	.48	.45	.41	.39	.36	.34	.32	.31	.29	.28	.26	.25	.24	.23	.22	.22	.21	.20	.19
350	1	1	1	1	1	1	.98	.85	.76	.68	.62	.57	.53	.49	.46	.43	.40	.38	.36	.34	.33	.31	.30	.28	.27	.26	.25	.24	.24	.23
400	1	1	1	1	1	1	1	.98	.87	.79	.71	.65	.60	.56	.52	.49	.46	.44	.41	.39	.37	.36	.34	.33	.31	.30	.29	.28	.27	.26
450	1	1	1	1	1	1	1	1	.99	.89	.81	.74	.68	.63	.59	.55	.52	.49	.47	.44	.42	.40	.39	.37	.35	.34	.33	.32	.31	.30
500	1	1	1	1	1	1	1	1	1	.99	.90	.82	.76	.71	.66	.62	.58	.55	.52	.49	.47	.45	.43	.41	.40	.38	.37	.35	.34	.33
550	1	1	1	1	1	1	1	1	1	1	.99	.91	.84	.78	.73	.68	.64	.61	.57	.54	.52	.50	.47	.45	.44	.42	.40	.39	.38	.36
600	1	1	1	1	1	1	1	1	1	1	1	.99	.92	.85	.79	.74	.70	.66	.63	.60	.57	.54	.52	.50	.48	.46	.44	.43	.41	.40
650	1	1	1	1	1	1	1	1	1	1	1	1	.99	.92	.86	.81	.76	.72	.68	.65	.61	.59	.56	.54	.52	.50	.48	.46	.45	.43
700	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.93	.87	.82	.77	.73	.70	.66	.63	.61	.58	.56	.54	.52	.50	.48	.46
750	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.93	.88	.83	.79	.75	.71	.68	.65	.62	.60	.57	.55	.53	.51	.50
800	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.88	.84	.80	.76	.72	.69	.66	.64	.61	.59	.57	.55	.53
850	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.89	.85	.81	.77	.74	.71	.68	.65	.63	.60	.58	.56
900	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.94	.90	.85	.82	.78	.75	.72	.69	.66	.64	.62	.60
950	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.90	.86	.82	.79	.76	.73	.70	.68	.65	.63
1000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.87	.83	.80	.77	.74	.71	.69	.66
1050	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.87	.84	.81	.78	.75	.72	.70
1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.88	.84	.81	.78	.76	.73
1150	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.88	.85	.82	.79	.77
1200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.89	.86	.83	.80
1250	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.89	.86	.83
1300	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.90	.87
1350	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.90
1400	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93
1450	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.97
1500	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1550	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TABLE 3.4

PROBABILITY OF DETECTION IF c = 100m.

$$\text{Table Entry} = \begin{cases} \sqrt{d^2 - (100)^2}/\ell & \text{if } \sqrt{d^2 - (100)^2} < \ell \\ 1 & \text{if } \sqrt{d^2 - (100)^2} \geq \ell \end{cases}$$

d \ ℓ	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	1	1	.75	.56	.45	.37	.32	.28	.25	.22	.20	.19	.17	.16	.15	.14	.13	.12	.12	.11	.11	.10	.10	.09	.09	.09	.08	.08	.08	.07
200	1	1	1	.87	.69	.58	.49	.43	.38	.35	.31	.29	.27	.25	.23	.22	.20	.19	.18	.17	.16	.16	.15	.14	.14	.13	.13	.12	.12	.12
250	1	1	1	1	.92	.76	.65	.57	.51	.46	.42	.38	.35	.33	.31	.29	.27	.25	.24	.23	.22	.21	.20	.19	.18	.18	.17	.16	.16	.15
300	1	1	1	1	1	.94	.81	.71	.63	.57	.51	.47	.44	.40	.38	.35	.33	.31	.30	.28	.27	.26	.25	.24	.23	.22	.21	.20	.20	.19
350	1	1	1	1	1	1	.96	.84	.75	.67	.61	.56	.52	.48	.45	.42	.39	.37	.35	.34	.32	.30	.29	.28	.27	.26	.25	.24	.23	.22
400	1	1	1	1	1	1	1	.97	.86	.77	.70	.65	.60	.55	.52	.48	.46	.43	.41	.39	.37	.35	.34	.32	.31	.30	.29	.28	.27	.26
450	1	1	1	1	1	1	1	1	.97	.88	.80	.73	.67	.63	.58	.55	.52	.49	.46	.44	.42	.40	.38	.37	.35	.34	.32	.31	.30	.29
500	1	1	1	1	1	1	1	1	1	.98	.89	.82	.75	.70	.65	.61	.58	.54	.52	.49	.47	.45	.43	.41	.39	.38	.36	.35	.34	.33
550	1	1	1	1	1	1	1	1	1	1	.98	.90	.83	.77	.72	.68	.64	.60	.57	.54	.52	.49	.47	.45	.43	.42	.40	.39	.37	.36
600	1	1	1	1	1	1	1	1	1	1	1	.99	.91	.85	.79	.74	.70	.66	.62	.59	.56	.54	.51	.49	.47	.46	.44	.42	.41	.39
650	1	1	1	1	1	1	1	1	1	1	1	1	.99	.92	.86	.80	.76	.71	.68	.64	.61	.58	.56	.54	.51	.49	.48	.46	.44	.43
700	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.92	.87	.82	.77	.73	.69	.66	.63	.60	.58	.55	.53	.51	.49	.48	.46
750	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.93	.87	.83	.78	.74	.71	.68	.65	.62	.59	.57	.55	.53	.51	.50
800	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.93	.88	.84	.79	.76	.72	.69	.66	.63	.61	.59	.57	.55	.53
850	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.94	.89	.84	.80	.77	.73	.70	.68	.65	.63	.60	.58	.56
900	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.94	.89	.85	.81	.78	.75	.72	.69	.66	.64	.62	.60
950	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.94	.90	.86	.82	.79	.76	.73	.70	.67	.65	.63
1000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.99	.95	.90	.87	.83	.80	.77	.74	.71	.69	.66
1050	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.87	.84	.80	.77	.75	.72	.70
1100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.91	.88	.84	.81	.78	.76	.73
1150	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.95	.92	.88	.85	.82	.79	.76
1200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.89	.85	.82	.80
1250	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.92	.89	.86	.83
1300	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.89	.86
1350	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93	.90
1400	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96	.93
1450	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.96
1500	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1550	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TABLE 4

ESTIMATED NUMBER OF PLF's IN AREA R BY DIAMETER

c = 75 m.		
Diameter	Estimated Number of PLF's with Diameters > 75m.	Standard Error
100	39.29	28.10
150	11.11	10.60
200	5.41	3.03
250	5.44	3.08
300	19.48	5.29
350	35.35	6.30
400	26.84	4.74
450	15.51	4.14
500	26.78	3.46
550	10.76	.96
600	11.97	1.08
650	16.42	1.52
700	6.01	.10
750	3	0
800	9.64	1.02
850	5.79	1.18
900	6	0
950	6.17	1.37
1000	3.52	.88
1050	10.20	.48
1100	2.45	.81
1150	0	0
1200	1	0
1250	4	0
1300	1	0
1350	3	0
1400	0	0
1450	1	0
1500	2	0
1550	1	0
1600	2	0
1650	0	0
1700	1	0
1750	0	0
1800	1	0
1850	3	0
1900	2	0
1950	0	0
2000	0	0
2050	0	0
2100	1	0
TOTAL	300	32.41 STANDARD ERROR

TABLE 5

ESTIMATED NUMBER OF PLF's BY ZONE

ZONE	c = 75m.			
	Estimated Number of PLF's with Diameters > 75m.	Standard Error	Estimated Number of PLF's per 100 sq. km.	Standard Error
A	47	4.96	23.0	2.43
B (Two Disjoint Areas)	56	3.79	7.5	.51
C (Two Disjoint Areas)	69	5.24	2.2	.17
D	67	27.74	2.7	1.11
E (Two Disjoint Areas)	32	3.31	1.0	.11
F (Two Disjoint Areas)	29	14.35	0.2	.09
COMBINED (i.e. AREA R)	300	32.45	1.3	.14
Z	48	5.00	18.8	2.00

TABLE 6

ESTIMATED NUMBER OF PLF's IN AREA R

THAT HAVE ESCAPED DETECTION BY DIAMETER

c = 75m.	
Diameter	Estimated Number of PLF's with Diameters > 75m. That Are Hidden in Area R
100	37
150	10
200	3
250	3
300	11
350	15
400	11
450	7
500	6
550	1
600	1
650	1
700	0
750	0
800	1
850	1
900	0
950	1
1000	1
TOTAL	110

TABLE 7

PROBABILITY OF DETECTING ALL HIDDEN PLF's

Table Entry = Approximate probability that all remaining PLF's in Area R having diameters ≥ d meters will be found if the area is searched using sounding lines spaced ℓ meters apart.

d \ ℓ	c = 75m.									
	50	100	150	200	250	300	350	400	450	500
≥ 100	1	.00	.00	.00	.00	.00	.00	.00	.00	.00
≥ 150	1	1	.24	.01	.00	.00	.00	.00	.00	.00
≥ 200	1	1	1	.80	.35	.08	.00	.00	.00	.00
≥ 250	1	1	1	1	.87	.35	.03	.00	.00	.00
≥ 300	1	1	1	1	1	.70	.09	.00	.00	.00
≥ 350	1	1	1	1	1	1	.70	.08	.00	.00
≥ 400	1	1	1	1	1	1	1	.82	.20	.03
≥ 450	1	1	1	1	1	1	1	1	.91	.40
≥ 500	1	1	1	1	1	1	1	1	1	.93

The 1980 HMS Breadalbane Expedition

M.I. Mogg

Telefix Canada
Thornhill, Ontario

During the 19th century, several attempts were made to find a North West Passage from Europe to the Orient. The Franklin Expedition was the last and the largest of the British Admiralty expeditions and as with all previous expeditions it met with failure. Sir John Franklin and 129 of his men spent the winter of 1845-46 in Erebus and Terror Bays, at the South West tip of Devon Island - a latitude of almost 75° North. In the summer of 1846 the two expedition ships, *HMS EREBUS* and *HMS TERROR*, sailed to the Southwest and disappeared. As the years passed, over 40 ships sailed into the ice of the Canadian Arctic in search of Franklin's party. *HMS BREADALBANE* was one of those ships. She was built in Glasgow in 1843, displaced about 430 tons, was 120 feet long, and looked similar to the illustration shown in Figure 1.

In August 1853 the expedition ships, *BREADALBANE* and *PHOENIX*, arrived at Cape Riley where they met the *NORTH STAR*, the depot ship of Belcher's squadron. 130 tons of coal were unloaded from the *BREADALBANE* onto the flat shore at Cape Riley. On Sunday August 21st, the ice began to move in and the *PHOENIX* towed the *BREADALBANE* towards Beechey Island (the Phoenix was a reinforced, propellor-driven ship; whereas the Breadalbane was a wooden sailing ship). The ice moved so rapidly that it trapped the *BREADALBANE*, broke through the hull and sank the ship within fifteen minutes. Fortunately, there was no loss of life; however, the crew had little time to gather their personal belongings or offload the remaining cargo. The Second Master of the *PHOENIX* estimated that about 160 casks and packages went down with the ship.

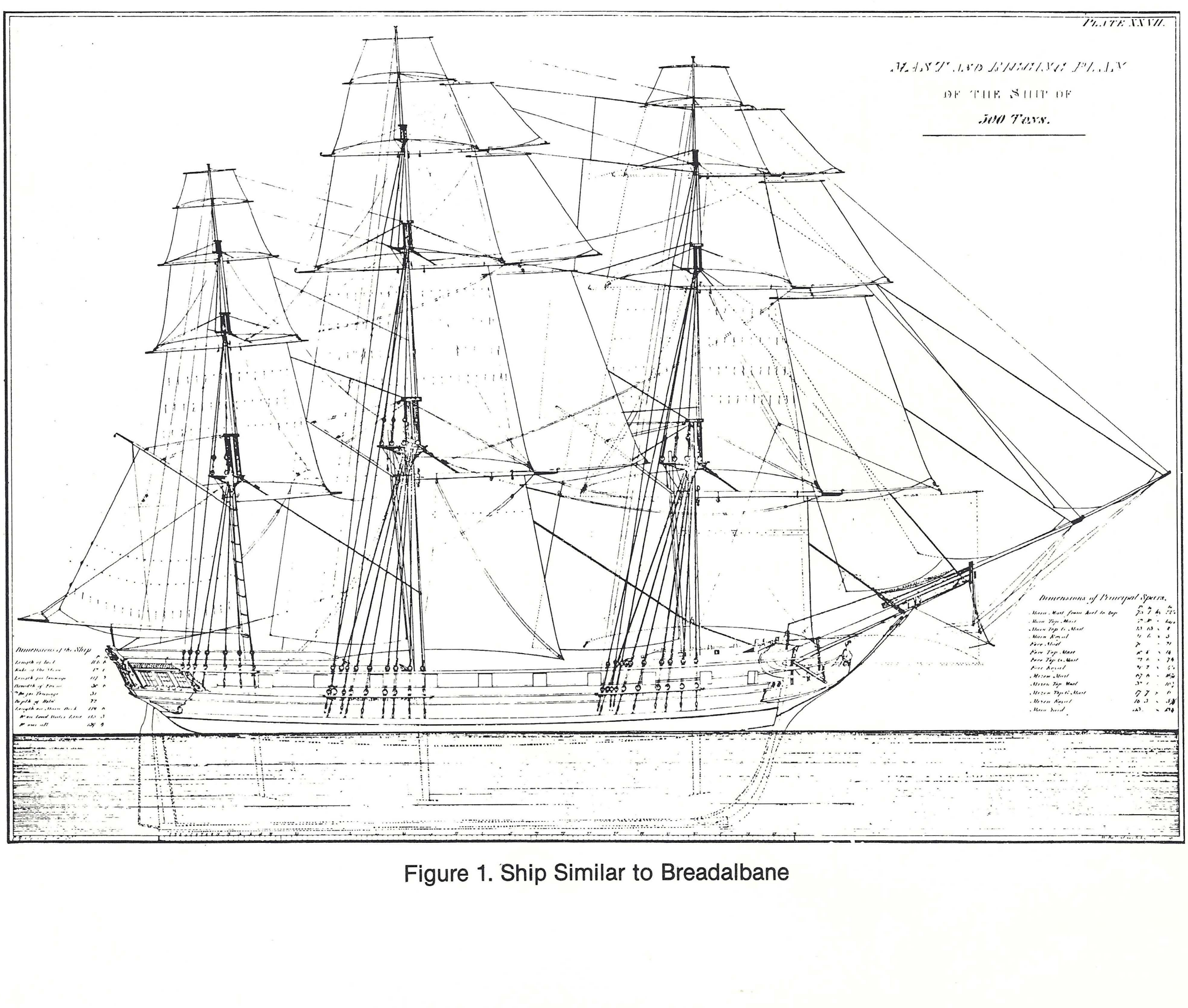


Figure 1. Ship Similar to Breadalbane

Figure 2. Recent Field Sheet of Erebus Bay

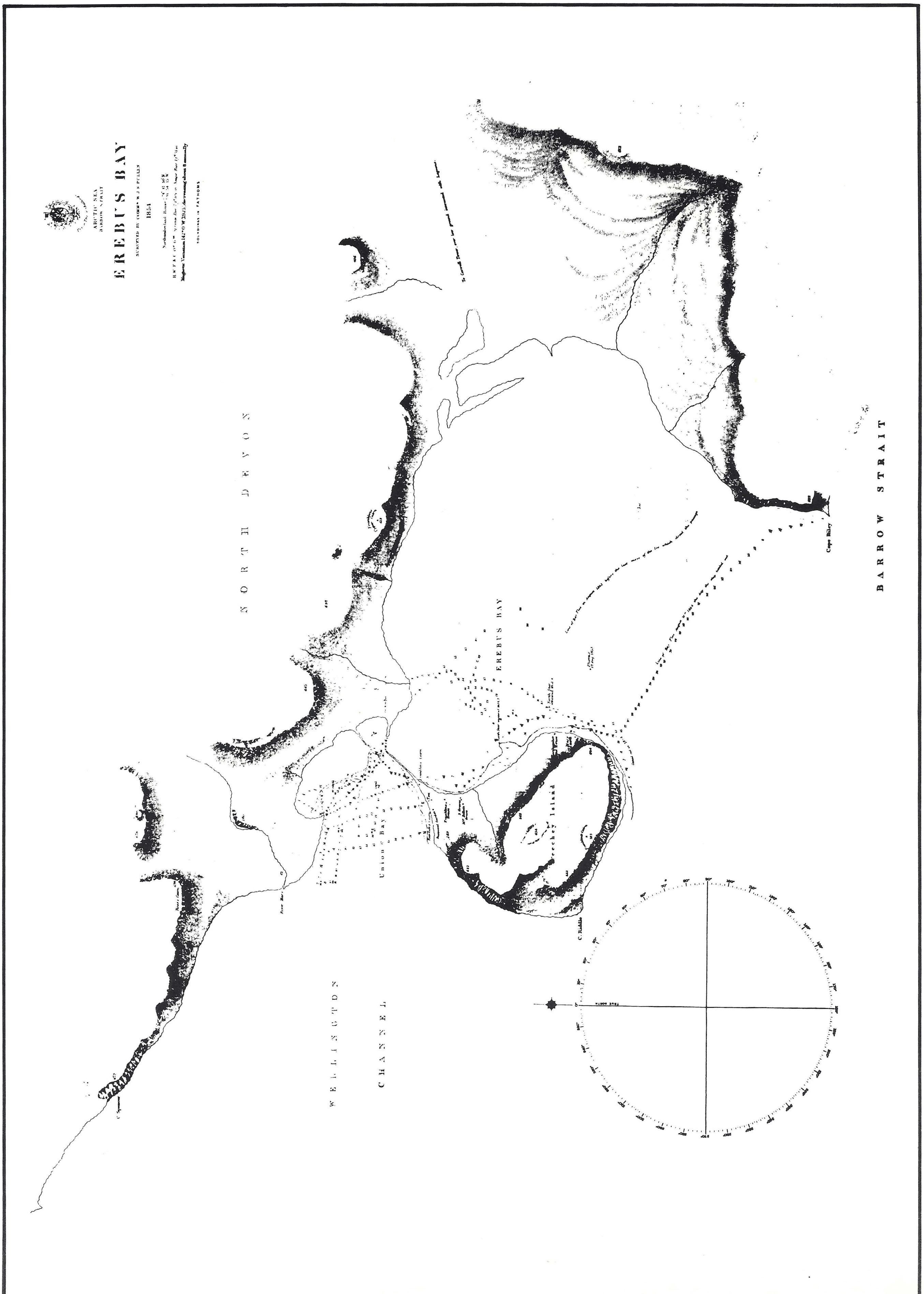


Figure 3. 1854 Admiralty Chart

Two recent expeditions, in 1978 and 1979, were mounted in an attempt to locate the wreck of the *BREADALBANE*. These were unsuccessful, partly because of adverse conditions in the area and partly due to inaccurate positioning equipment. It was decided that there would be one last attempt in August 1980 using Klein side-sweeping sonar and a Tellurometer MRD1 positioning system. TELEFIX CANADA was asked by Dr. J. MacInnis of Underwater Research to loan the Tellurometer equipment and an operator to provide coverage of the designated area and to accurately position the wreck if it was found. I willingly became the designated operator because of my technical interest and, being ex-Royal Navy, I also wanted to participate in the possible discovery of a Royal Navy wreck.

Charts of the area were provided by the Canadian Hydrographic Service together with tide data in Erebus Bay at the time of the sinking. The 1961 Hydrographic chart of the area (Figure 2) is quite a contrast to the 1854 version produced in England (Figure 3).

The members of the expedition were Dr. J. MacInnis, G. Kozak of Klein Associates Inc., Morris Haycock - the Arctic Geologist and artist, Emery Kristoff and Al Chandler of the National Geographic Association - part sponsor of the expedition, Chris Matthews - a student from Upper Canada College, and myself. We were later joined by Geoff MacInnis, and Bill Mason of the National Board. After arriving at Resolute in the early hours of August 13th, the equipment and personnel were ferried by helicopter to the *CCG JOHN A. MacDONALD* which had been kindly placed at our disposal.

Figure 4. Side Scan Sonar Trace

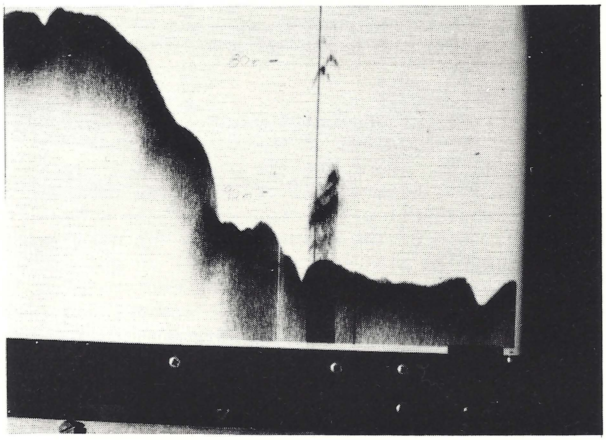


Figure 5. Echo Sounder Trace

While en route to Beechey Island the various instruments were installed on the ship and since the ice conditions were fairly good, the search began on the evening of August 13th.

Bearing in mind the 1853 documents, we decided to cover the area along the south side of Beechey Island, with tracks parallel to the coast and with offset spacing, to ensure complete coverage with the side-sweeping sonar. The total system consisted of an MRD1 system with shore stations at Cape Riddle and Cape Riley, a Centronics alpha-numeric printer to print all range data, a Tektronics track plotter, the Klein side-sweeping sonar, and a Kelvin Hughes echo sounder. The first two legs of the search showed that the sea bottom in the area was scoured with many gouges. Nearing the end of the third leg, the trace of an unidentified object on the bottom appeared on the Klein recorder and a series of extra fixes were taken. On returning to this position, a clear outline of the wreck was obtained which also showed up clearly on the Kelvin Hughes record. On the Klein recorder, the shadow produces more information than the plan view, and in this case the shadow showed that two masts were still standing on the almost-upright wreck (Figure 4). The echo sounder trace gave us not only the depth of the wreck at 95 metres, but also showed the tops of the masts quite clearly (Figure 5). We had accurately located the most Northerly shipwreck ever discovered!

August 14th was spent crossing the wreck at different angles in order to obtain various views, and to mean out the position differences caused by the distance between the MRD1 Antenna on the ship and the Klein "fish", which was towed behind the ship (Figure 6).

Telegrams of congratulations were received from the Prime Minister and the Governor General. The Governor General suggested that the *EREBUS* and *TERROR* should be next on the list for discovery but the lack of data on these ships may make their discovery a much more difficult task.

On August 16th, we decided to grapple the wreck and send down underwater video and 35 mm cameras to verify the finding and the condition of the ship. From a ship's launch, two lines and marker buoys were secured to the wreck; but during the night both were carried away by the ice. This exercise was repeated the following day and successful video and 35 mm photographs were obtained clearly showing the wreck to be in a good state of preservation.

The entire operation indicated that the Klein/Tellurometer MRD1 combination is ideal for inshore wreck hunting. There are two phases to a wreck search of this nature, the initial area coverage and the subsequent criss-crossing of the wreck location. One of the programmes in the MRD1 enables the operator to plot the ships track at any scale. This was particularly useful since the scale of 1:36,000 used for the first phase was changed to 1:18,000 during the second phase where maximum accuracy was required to direct the search ship over the wreck.

Recent shipwreck discoveries have been stimulated by the prospects of treasure and the possibility of making a fortune. *HMS BREADALBANE* is of historical value only, treasure of a different sort. The cargo should be well preserved in the cold Arctic waters and its recovery should produce a mass of information on the marine clothing, equipment and food of the period. It is even possible that some of the food on board will still be edible. It is hoped that in the Spring of 1981 some of the cargo will be salvaged. Being a Royal Navy ship, there is probably some Naval Rum on board and I hope to take part in this final phase!

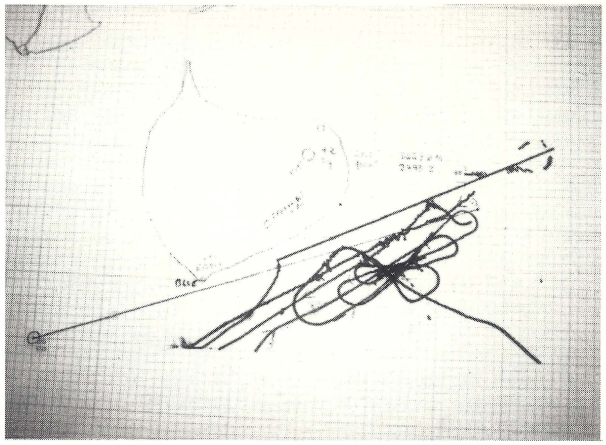


Figure 6. Plot of Ship's Track

The Field Sheet as an Inefficient Medium

M.J. Casey

Central Region
Canadian Hydrographic Service
Burlington, Ontario

In many ways the science of Hydrographic surveying can be considered a classical form of statistical analysis. If statistics can be defined as the science of the design and execution of a sampling program for the purpose of modelling a complex, immeasurable population, then this is clearly the case. The population in this instance is the actual lake or sea bottom and the sampled portion is the sounding track - either descrete as in the case of spot soundings or continuous as in the case of the analog depth recording. The initial problem is the same in both cases, i.e., to design a suitable sampling program which will best bring out the characteristics of the true population. Just as the hydrographer can never hope to fully model the lake bottom, so too the statistician can never hope to truly define the population. In fact, it is not the function of either profession to do this. The hydrographer is primarily interested in navigation and is quite prepared to bias his model in favour of shallow depths if he feels that this bias will improve the usefulness of the chart. His function is to show the least depth at every sounding location and in many cases the depth of water is considerably deeper in the geographic area where the sounding is shown. To minimize costs both professions also have the goal of best representing the hidden population with the minimum number of samples. But three areas where the professions differ are in the collection, analysis and display of their data. In these areas, I feel the statistician does a much better job.

We are both interested in anomalies - shoals in the case of hydrography. Here we take the simple route and plot all of our significantly shallow soundings. The statistician on the other hand has a much more flexible game plan. He begins by designing the best possible sampling program given his initial information, but he can and often does change this to exploit unforeseen anomalies. He does this by analysing his incoming data and by testing and re-testing various hypotheses, constantly narrowing his scope and increasing his resolution until the hidden parameters are defined. Taking a specific example, this is analogous to the Lake Erie hydrographer faced with the prospect of surveying the very gentle slopes of the north shore (with few anomalies) constantly widening his line spacing in predictable areas and tightening up in shoaler more unpredictable areas - something which is not allowed under the traditional rules. A strictly regimented line spacing is defined well before the survey begins and although a narrowing of line spacing is allowed, it is at a time penalty, for the hydrographer is *not* allowed to compensate with a wider spacing in the predictable areas. Thus the survey manager is often faced with a dilemma - to slow progress in order to thoroughly investigate an area or to continue, having at least "followed the book", and acquire his minimum coverage.

Another penalty - and a severe one in terms of point efficiency* - is in the display of this information. There is only room for so many soundings in a particular area - no matter how complex. Now it is the chief function of a hydrographer to find the least depths in his survey area. He is guided in this search by his sounding data. Questionable areas are sounded at a greater intensity and many extra miles are logged in order to truly map the shoals. Thus many extra sounding miles have to be run in order to change even one original sounding and often no soundings are changed at all; the excess mileage merely satisfies the hydrographer that no shallower depths exist in the area in question. In fact, this represents to me a great limitation on the quality and overall usefulness of the field sheet. What is required, in my opinion, is a methodology whereby the shallow sounding bias can be safely removed and *all* logged data used in the definition of the lake bottom model. The statistician, when faced with a dynamic continuous population, will naturally look for the best dynamic, continuous model - a numerical model or system of equations. We hydrographers can also model our population with a continuous model by using some form of automated contouring. The usefulness of a fully contoured chart has already been demonstrated by A. Pittman and R. Cashen in their paper presented at the 16th Annual Hydrographic Conference in Burlington, 1977. Now the time has come to use, either in the field or back in the office, a suitable, automated, contouring package.

Consider for a moment what we are now doing on automated surveys. We measure with our survey vessels a continuous, depth profile. Our real time logging software then reduces this to a representative sounding every second, usually a 5-1 reduction. Off-line processing typically reduces this further by 30-1 and overplot removal probably reduces the data file by another 10-15%. The result of all of this processing is the creation of a data base of descrete sample points - each point representing the least depth of water beneath its plotted position. At this stage the sheet is manually contoured and any semblance of scientific method is now swamped by the contourer's subjective "feel" for what he is doing. This subject opens the proverbial "can of worms" as far as hydrographers are concerned. In ambiguous areas the resulting contour choice often has more to do with game theory than geomorphology! In fact, it has often been said that two hydrographers given the same data set (of average complexity) will *not* derive the same contour set. But surely this is

* point efficiency is defined as the cost of the survey per sounding *used* on a published chart.

all wrong! The descrete samples (soundings) can be taken from the contour set, if this is desired, but the reverse is *not* a valid technique. Yet it is this contour set which is used as the basis for the contours on the chart. Surely the ideal is to use all soundings acquired to produce the most representative bottom model possible. This can only be accomplished by using an automated contouring package. Then the same contours derived for the field sheet can be used for the chart. By its very nature the contour algorithm uses all the information given it, regardless of some arbitrary, survey scale-dependent, overplot constraint. In fact, the more information the system is given the better the resulting contour set. *Now* the OIC can expect a real payoff for all his shoal development soundings, his check-lines and interlines as he is assured that *all* logged information will be used in the generation of the contour set. Now *that* is efficiency!

The Canadian Princess

R.W. Sandilands

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Canadian Hydrographic Service
Sidney, B.C.

In a previous article (Charlie Golf Foxtrot Quebec, Edition 20, pp. 1-3) we left the *CSS WILLIAM J. STEWART* in mothballs awaiting bids to the Crown Assets Disposal Corporation.

Shortly after that article went to press she started a new career on the West Coast. Purchased by Bob Wright, a Victoria businessman, for a sum "in excess of $100,000" she was towed from the Institute of Ocean Sciences, Patricia Bay to the Inner Harbour of Victoria for an extensive refit. Incidentally, Mr. Wright also recently acquired the ex-Hydrographic vessel *MARABELL* for charter fishing in the Hakai Pass area of B.C. and so has a greater year round 'hydrographic tonnage' than the Hydrographic Service with its time shared only tonnage!

The Government retained use of the name *WILLIAM J. STEWART* and it was not until the end of the refit that the *STEWART* was reborn as the *CANADIAN PRINCESS*.

The plans for her were ambitious and innovative, in character with her new owner who also owns Oak Bay, Pedder Bay and Bosun's marinas as well as other tourist enterprises in the city and in Oregon. In addition to these activities Mr. Wright finds time to be a Victoria Alderman and Director of B.C. Steamships.

Ucluelet and Tofino are the two settlements at the extremities of the Pacific Rim National Park which is fronted by Long Beach, a magnificent open sandy beach, and also includes the Broken Group in Barkley Sound. Opened in the early 70's the park is accessible by road from Port Alberni and is drawing a large number of visitors to the area with an ever increasing demand for tourist facilities. In an astute move Wright has converted the old *STEWART* into a floating hotel with accommodation for 80 guests including a dining room and licenced lounge facilities.

On completion of her refit the *CANADIAN PRINCESS* was towed to Ucluelet where a berth had been dredged for her in a mud basin adjacent to the Government floats and alongside the main highway into town. Tied up alongside she became the focal point for the first Canadian West Coast sport-fishing operation catering to deepsea salmon buffs. Running tender to her for this activity are four 43 foot Delta fibreglass boats each capable of carrying fourteen anglers out to the prime salmon fishing areas in and off Barkley Sound. The boats, the *UCLUELET PRINCESS*, *SALMON PRINCESS*, *NOOTKA PRINCESS* and *BARKLEY PRINCESS*, are well fitted out with radar, echo sounders, radios, Loran C, a small galley and comfortable cabin.

In addition to the morning fishing trips these boats run afternoon nature trips through the Broken Islands in Barkley Sound and sunset cruises off Long Beach. Scuba fishing cruises are also contemplated.

The former chart room and surveyors lounge area have become a licenced lounge appropriately called The Chart Room Lounge. A bar occupies the port side aft and the brass rails which used to be fixed to the chart tables have been joined to form a foot rail for the bar. The original panelling has been retained and the bar features a blow-up of Captain Richards' 1861 chart of Barkley Sound. The square ports have been retained and the old slide blinds have been removed and replaced by curtains. A second companionway has been added forward so that there are now two leading from the main deck level to the former hydrographers' quarters area.

All this area has been opened up and now forms The Stewart Room. This is the dining area and is presided over by an enlarged photograph of Mr. William J. Stewart. It can accommodate 90, seated at circular tables with "captains chairs". Again the essential essence of being onboard a ship has been retained. The channel plating, ventilator system, sundry pipes etc., are left open to view. The old surveyors' pantry has been enlarged by adding the chief steward's cabin to the area.

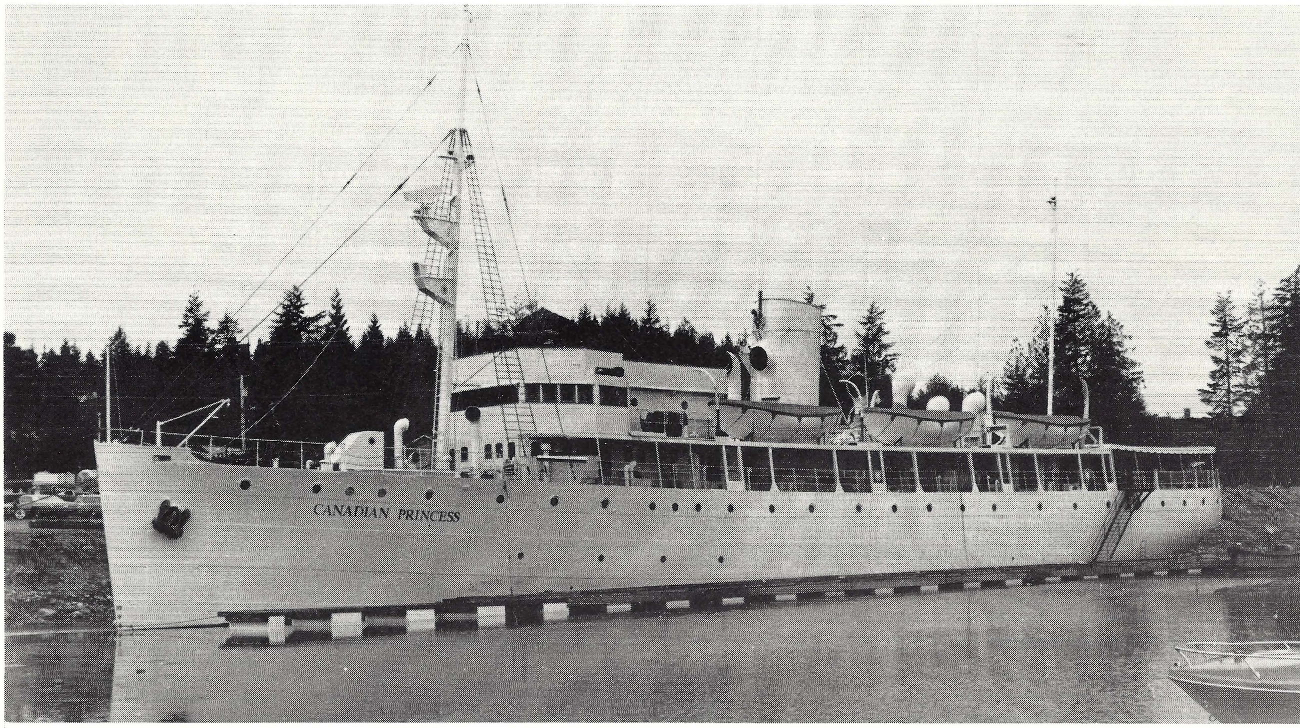
Disappointingly the selection of photographs decorating the bulkheads of these areas show little of the ships former career as a survey vessel and are almost entirely devoted to shots of fishermen displaying their catch, but then that is the aspect of her career that Wright wishes to promote - come here and catch the big ones. Despite a poor season for salmon, reports are that Wright's fishing captains are doing just that.

The upper deck has seen few changes though the addition of canvas 'directors chairs' on the after deck which is now covered by an awning, provide a touch of colour and a pleasant [illegible] to sit on deck, glass in hand and admire the west coast scenery.

The former Master's and Chief Officer's cabins aft of the bridge are now accommodation for the Captain and his wife. Sadly the old "hen house" or upper bridge plotting table on the upper bridge is gone but only the purists would claim that odd structure did anything for her silhouette.

In place of the sounding launches and lifeboats Wright has added six fibreglass boats thus giving the outward appearance of a ship ready for sea.

There are few changes in the cabins which are now staterooms of various sizes and old crew members



The Canadian Princess *Photo Credit: Bob Wright*

will have memories of the after lower crew's mess which retains its old nickname of The Glory Hole, but with the added stature of being called a stateroom where six fishing buddies can get accommodation at less than $10 per head.

The radio room, operator's cabin and 3rd Mate's cabin have been knocked into one and form the general office and reservation desk.

At an opening ceremony on 21 June, Wright launched the *CANADIAN PRINCESS* on her new career in a first class fashion. A superb buffet and open bar would have gladdened the heart of hydrographers who sailed onboard on her 'dry' days with depression day Government rations. Three pipers from the Canadian Scottish skirled a welcome to the more than two hundred guests from the surrounding area and those flown in from Victoria. Representatives of the Provincial Government Department of Travel Industry, the City of Victoria and local dignitaries attended and wished the new owner success in his new venture.

Wright confessed that the venture started as a dream and a labour of love for him and his wife Marti who was responsible for the interior decor, and that the final bill for the venture was between one and two million dollars.

Canadian hydrographers can be pleased that their old ship did not find her way to the scrapyard and that she has a new lease of life on Canada's west coast where during her active hydrographic life she made the coast safe for navigation. Like many an old hydrographer she will spend her retirement years in peace "gazing over the water with a glass in her hand". We wish her well in her new endeavour.

Note: Reservations can be made through:

Oak Bay Marina
1327 Beach Drive
Victoria, B.C.
V8S 2H4 *(604) 598-3366*

Or Ucluelet *(604 726-7771*

Notes

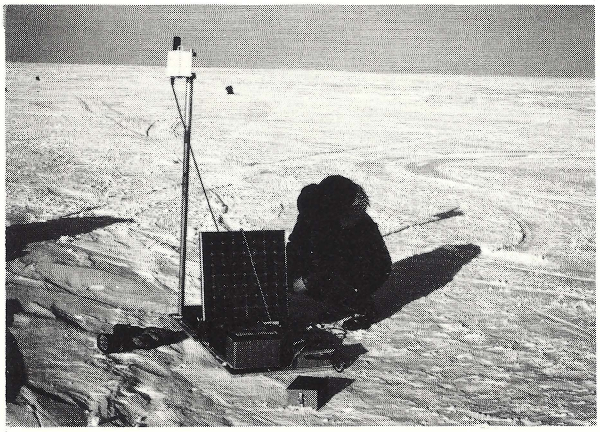
Solar Panels—Arctic Power

During the tracked vehicle portion of the 1980 winter survey of M'Clintock Channel in the Arctic Islands, the Canadian Hydrographic Service Central Region survey party, headed by Mr. Paul Davies, used solar panels to charge the batteries at the Mini-Ranger transponder sites. The system operated successfully for a period of twenty-two days and produced an estimated saving of 11 hours of helicopter time.

The details of the system have been reported by R. D. Coons and E. O. Lewis at the 1980 C.H.S. Convention in Halifax. The system, as it was used in the Arctic, consisted of:

1) two 100 amp. maintenance-free, lead-acid batteries
2) one timer
3) one Solarex High Density Unipanel.

Each solar panel weighs 11 pounds and is 24 x 24 x 1 1/4 inches in dimension. The panel has a 12 or 24 volt output at the panel junction box. The voltage at peak power (24 volt output) is 28 volts and the current at nominal voltage is 1.35 amps. The system is portable enough to be transported by a 206B Jet Ranger and set up in less than 10 minutes with a minimum of tools. The timer can be preset in the field office, and a small internal battery provides power until it is connected to the site installation.



Before installation in the field, the system was tested at the Hydrographic Base Camp. A Mini-Ranger transponder, two 100 amp. batteries, a timer, and a solar panel were set up at the end of the air strip. The transponder was interrogated by a range console at the camp for 12 hours each day over a period of 12 days. The system was shut down by the timer during the 12 hours of darkness to conserve battery life. During the test, the system consumed approximately 100 amp.-hours and the solar panel had replenished 48 amp.-hours.

Later the system was moved to the area of the tracked vehicle survey for a period of 22 days. During this period, the batteries were not changed and the only visits to the transponder sites were to get readings from the amp.-hour meters on the solar panels.

The solar panels proved to be an efficient method to power the Mini-Ranger positioning system during the tracked vehicle survey. Since progress with the tracked vehicle was slow, the transponders remained at the same sites for long periods of time. Although a helicopter was still required to ferry the crew to the tracked vehicle, a side-trip to replace batteries was no longer required. As a result, the tracked vehicle crew and the hydrographer waiting for the helicopter to return to camp could both get an earlier start. During this survey, an estimated 11 hours of helicopter time ($290/hour) were saved and there was no down time because of dead batteries.

Martin Karlsen as the Benjamin Bowring

Canadian hydrographers at the Atlantic and Central Regional offices will remember the charter vessel *MARTIN KARLSEN*. Last year the ship was bought from Karlsen Shipping Co. by the British Trans Globe Expedition. This expedition, which has considerable commercial financial backing intends to circle the globe over each of the Poles. The expedition is lead by Sir Ranulph Fiennes. Recent word indicates that *BENJAMIN BOWRING*, which is the new name for *MARTIN KARLSEN* deposited a five man team at Sanae in the Anarctic last January. A party of three will then cross the continent and be picked up by the ship on the far side. The ship is then to sail to the Western Coast of the U.S.A. and Canada where the party will go overland again, cross the Arctic Islands and Polar Ice Pack, and be picked up by ship in the vicinity of Spitzbergen.

International Symposium on Positioning a Success

An International Symposium on Positioning at Sea took place in April, 1980, at the University of Southampton, England. The National President of CHA attended the conference, along with more than 140 other delegates representing 12 countries. Five Canadians were on hand to present four papers during the three day symposium. The 19 papers covered various subjects ranging from satellites to Loran-C, from industrial offshore positioning requirements to positioning relative to the seabed. Copies of each paper were distributed to conference delegates when they registered. The fact that the paper had been read before or during the presentation seemed to stimulate more than the usual amount of discussion. An interesting manufacturers' exhibit complemented the proceedings.

The symposium was co-sponsored by the CHA, but its success was mainly due to the hard work of The Hydrographic Society, although the weatherman might claim part of the credit for being so co-operative. Congratulations on a fine effort.

Copies of the conference proceedings, price £20 each, are available from The Hydrographic Society, North East London Polytechnic, Forest Road, London E17 4JB, England (Tel: 01-590 7722). North American subscribers may obtain copies, price US $45 each, from the Society's American Branch, 6001 Executive Boulevard, Rockville, Maryland 20852, USA (Tel: (301) 443 8013).

Canadian delegates shown above were, l to r, Adam Kerr, Dave Wells, George Macdonald, Dave Gray, missing - Rick Bryant

Surveying and Mapping 81

The UK National Land Surveying and Mapping Conference will be held at the University of Reading from March 30th to April 3rd, 1981. The program of events will include eight half-day technical sessions, an exhibition of instruments and equipment, social events, ladies tours and a display of mapping. For further information write to:

Survey and Mapping 81
The Royal Institution of Chartered Surveyors
12 Great George Street
Parliament Square
London SW1P 3AD

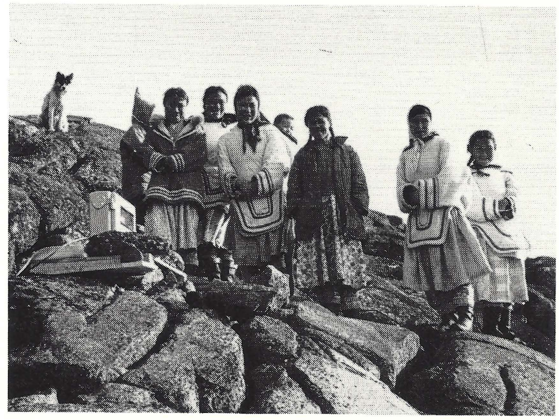
Admiral Munson Re-Elected President of Hydrographic Society

Rear Admiral Robert C. Munson, NOAA, Associate Director, Office of Fleet Operations of the U.S. National Ocean Survey, has been re-elected President of The Hydrographic Society.

As Associate Director, Office of Fleet Operations, Admiral Munson is responsible for the management of the fleet of 25 ships of the National Oceanic and Atmospheric Administration (NOAA). These vessels support programs that include coastal research, fisheries assessment, oceanography and hydrography throughout U.S. waters. Prior to this appointment, he was Director of the Atlantic Marine Center of the National Ocean Survey with responsibility for the management of the east coast fleet of ships.

Admiral Munson became President of The Hydrographic Society in June of last year when he succeeded the present Hydrographer of the Navy, Rear Admiral D. W. Haslam, CB, OBE.

That Ott to Do It!



The interested group of people shown above were gathered to watch Ab Rogers (who is familiar to all in the Canadian Hydrographic community, I'm sure) install an Ottboro tide gauge. The year was 1964 and the location was Cumberland Sound near Pangnirtung. The Ottboro case is located in front of the ladies, slightly to the left of centre.

Letter to the Editor

Visit to Mr. F.C.G. Smith— Retired Dominion Hydrographer

On June 9, while visiting the Nova Scotia Land Survey Institute and a field party at Yarmouth, I had the pleasure to call on Mr. F.C.G. Smith, retired Dominion Hydrographer. Mr. Smith and his wife live in a fine old house on the main street of Annapolis. Although he is now quite elderly I found him to be very alert. He was Dominion Hydrographer from 1952 to 1957 and continues to take a keen interest in the Canadian Hydrographic Service.

I had a long and interesting talk with him, recalling his work in Hudson Strait and his later service in England during the First World War. He started in the Army and later obtained a commission as a lieutenant in the Navy as a result of a visit to the then Hydrographer, Admiral Parry.

Mr. Smith keeps in contact with Colin Martin and was visited not long ago by Sandy Sandilands during Sandy's research into the history of the C.H.S.

A matter for which we, particularly in the Atlantic Region, must be thankful is that it was Clifford Smith who was largely behind the acquisition and design of our major survey resource, the C.S.S. BAFFIN.

Adam J. Kerr

News from Industry

New Loran C Navigation System from Internav

Internav recently announced its new LC-360 LORAN-C Navigation System, a compact, advanced technology unit combining unsurpassed accuracy with operating simplicity.

The LC-360 displays vessel positions to a tenth of a second of latitude and longitude. This precision stems from a high accuracy receiver, which measures the transmitted LORAN signals to hundredths of microseconds.

The new LC-360 offers several other major benefits. The system performs instant conversion of LORAN time differences to latitude and longitude, and vice versa. A forty waypoint memory allows for operational flexibility and route planning, with an "instant entry" capability which allows fishing marks, diving locations and other positions of interest to be instantly stored as waypoints and accurately returned to again and again. The LC-360's non-volatile memory also stores LORAN chain number, secondaries, waypoints and all other data even after the set is turned off. For the next voyage, the operator need only touch the ON button for full LORAN service.

At all times, speed over the bottom and course made good are instantly available, and all other navigational functions such as Waypoints Selection, Range Bearing, TIME-TO-GO and Cross Track Deviation are quickly and easily selected.

Design emphasis has been placed on making the LC-360 a highly accurate, easy to use navigation system, with minimum risk of operator error. The LC-360's clean, uncluttered instrument face with its simple, single function keypad, shows the success of this approach. There are no "Hidden Controls".

Internav's exclusive steer command is also a feature of the LC-360. Steer command supplies clear, unambiguous indications to the helmsman that he is precisely on his required track, or if he deviates, which way he should steer to regain track.

An extended capability package is available, giving the operator his choice of course and bearing relative to true or magnetic north, range and cross track error in nautical or statute miles, or yards or metres, speed in knots or MPH, GMT or local time plus stop watch, autopilot coupling, and, looking to the future, special position reporting outputs for marine traffic control.

The LC-360 unit measures 12 1/2 inches by 5 inches by 11 inches, weighs 11 pounds, and needs only 30 watts of power.

New 500 kHz Side Scan Sonar from Klein

The new Klein Associates 500 kHz Very High Resolution Side Scan Sonar now provides the capability to detect, detail, and classify small objects and ocean floor geology not before obtainable with standard Side Scan Sonars.

The increased capability can be attributed to the higher operating frequency of 500 kHz, five times the industry standard of 100 kHz, and the unit's very narrow horizontal beamwidth of 0.2 degrees and very short pulse length of 3 centimeters.

The ability of the new Side Scan Sonar to detect and detail objects is best illustrated in a comparitive evaluation of Side Scan Sonar records made with both the 100 kHz and the 500 kHz Side Scan Sonars of a four-rung wooden ladder. The ladder, constructed of 5 cm (2 inch) by 7.5 cm (3 inch) wooden frames, was barely detected by the 100 kHz unit, yet was sufficiently detailed by the 500 kHz unit to permit object classification, including the correct number of rungs.

Klein Associates has designed the new 500 kHz Side Scan Sonar so that it can be deployed with existing Klein equipment and can be interchanged with the 100 kHz Side Scan Sonar during field operations without difficulty in several minutes.

Marble Island, Hudson Bay, 1955

CHA Personal Notes

Ottawa Branch

Bob Steel, Production Control, is on education leave for a second year; *Jim Bruce*, Nautical Information, is back after 4 months sailing with CSS *BAFFIN* in Conception Bay and Ungava Bay; *Sheila Acheson* has won a competition in Tides, Currents, and Water Levels; *Gerry Jasky* has transferred to Training and Standards; *Michael Jennings*, a term employee in Geoscience Mapping, left Ottawa for Patricia Bay where he took up a permanent position in September.

Central Branch

Bryan White joined Central Region in September as Head of the Tidal Instrument Development Section, coming to us from the engineering division of Environment at C.C.I.W.; *Frank Hall*, hydrographer extraordinaire, left the employ of C.H.S. this past summer to take up a teaching post at the St. John's Institute of Trades and Technology - break a leg, Frank; *Reg Lewis* will head back east in the new year, after a 9 year stay in Central Region, to take up the position of Manager, Hydrographic Planning and Records in Atlantic Region; *Dave Pugh* has just completed an Honours B.Sc. in Geophysics at the U. of Waterloo - congratulations Dave; at the other end of the road *Geoff Thompson* has just started a degree program in Hydrographic Surveying at the Erindale campus of the U. of Toronto - good luck, Geoff.

Pacific Branch

The *10th Annual Canadian Hydrographic Invitational Golf Tournament* saw 48 golfers competing for numerous prizes donated by the 23 sponsoring companies -- *Brian Rands* shot a 71 taking top honours; our softball team, the *I.O.S. Mariners*, have completed another successful season (27 W, 10 L, 3 T), finishing it off in great form by earning 1st place in the 1st Annual D.S.S. Tournament; Hydrographers *Rod May* and *Meiric Preece* resigned this past summer, both attending U.B.C. in the pursuit of their new careers; *Ken Halcro*, BCIT Survey graduate, has joined CHS Pacific; *Mike Woods* is off to the University of Calgary on U.T.P; news from the Western Arctic Survey aboard *PANDORA II* indicates that a very successful membership drive has pursuaded numerous neophytes to leap into the ice infested waters for the privilege of joining the elite company of the Beaufort Sea Polar Bear Club.

Obituaries

Jan Kozaczynski

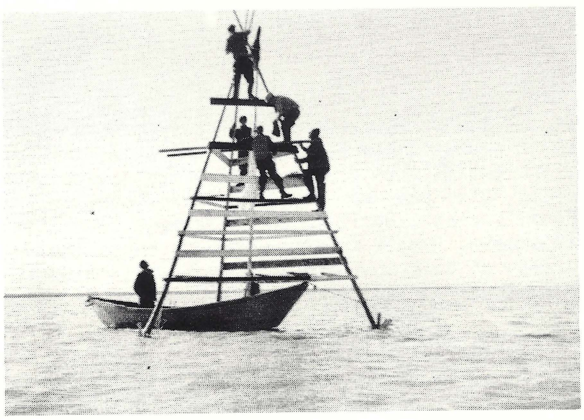
Jan Kozaczynski died suddenly in hospital in Burlington on May 16, 1980. He had worked as an instrument development technologist with the Tidal Instrument Development Section of the Central Region office of C.H.S. from 1972 until just a few days before his death.

Jan was born in Poland in 1923 and spent his early years there, learning the trades of machinist and aircraft instrument technician. Few of us knew that he had also obtained a license as a glider pilot while still living in Poland. Jan migrated to Canada in 1952 and, prior to joining C.H.S., worked for a number of firms in and around Ottawa specializing in aircraft and surveying instrumentation.

Jan will be remembered by Central Region staff for his prowess as a machinist and for his willingness to help out all comers with problems concerning instrument design and maintenance. He was particularly adept at making our workhorse tide gauge, the Ottboro, run. Jan will also be remembered for his ability as a gardener and for his willingness to share the results of his labour in this field as well. He will be missed by all of us in C.H.S. who had the opportunity to work with him.

Hugh Tingley

Hydrographic Service staff were saddened to hear of the death of MOT helicopter pilot Hugh Tingley on June 26th, 1980. Hugh participated in many hydrographic and oceanographic surveys in Central and Atlantic Regions of C.H.S. He worked aboard both the *BAFFIN* and the *HUDSON*, as well as with numerous shore parties in locations extending from the Great Lakes to Hudson Bay. Hugh's expertise, co-operation and enthusiasm will be greatly missed by all hydrographers who knew and worked with him.



Fort Albany, James Bay, 1956

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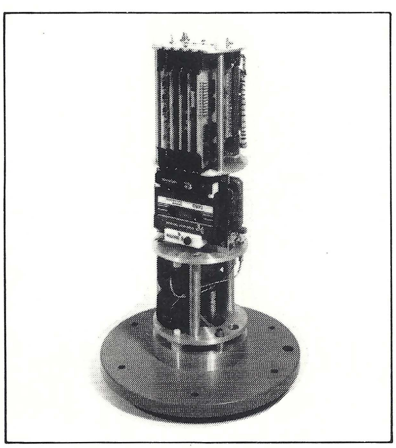

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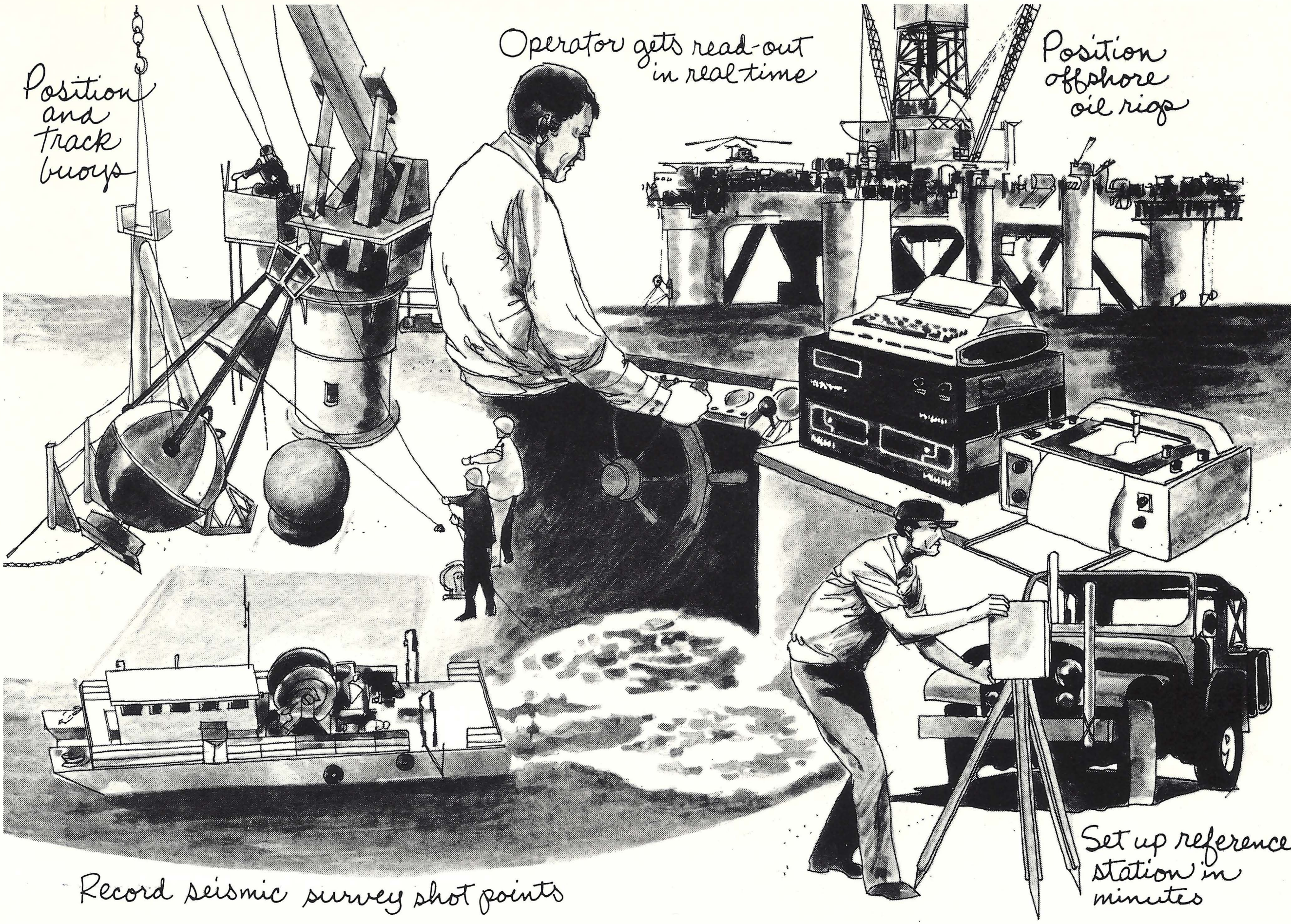
Zulsdorf, Dr. G., Haumann und Zulsdorf, Germany



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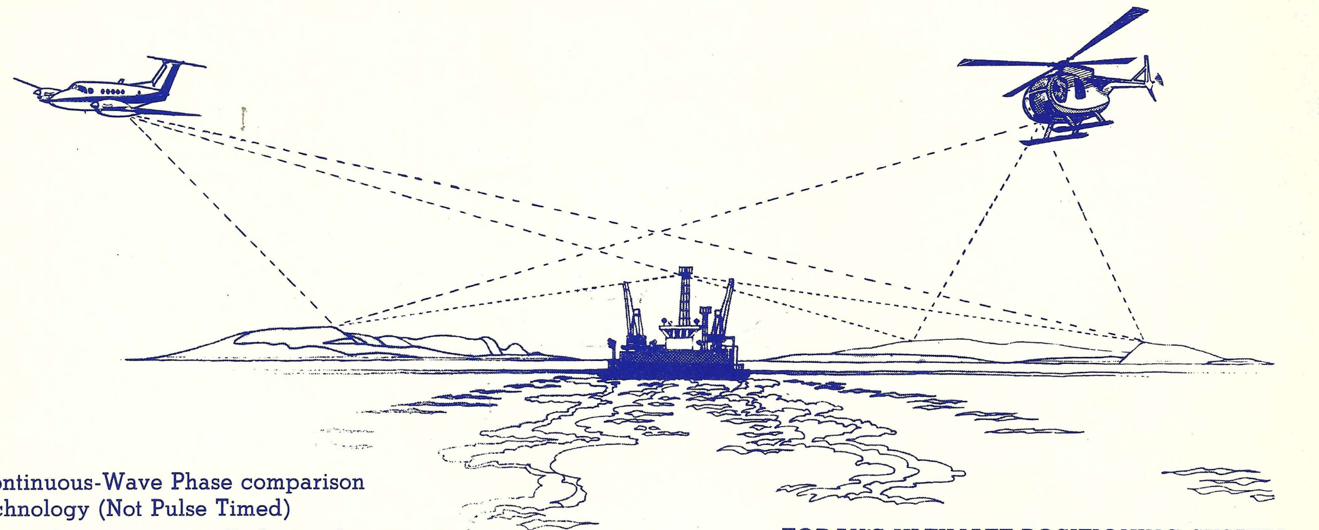

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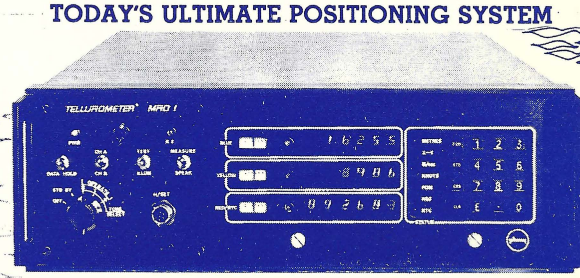

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