Edition No. 35, APRIL, 1987

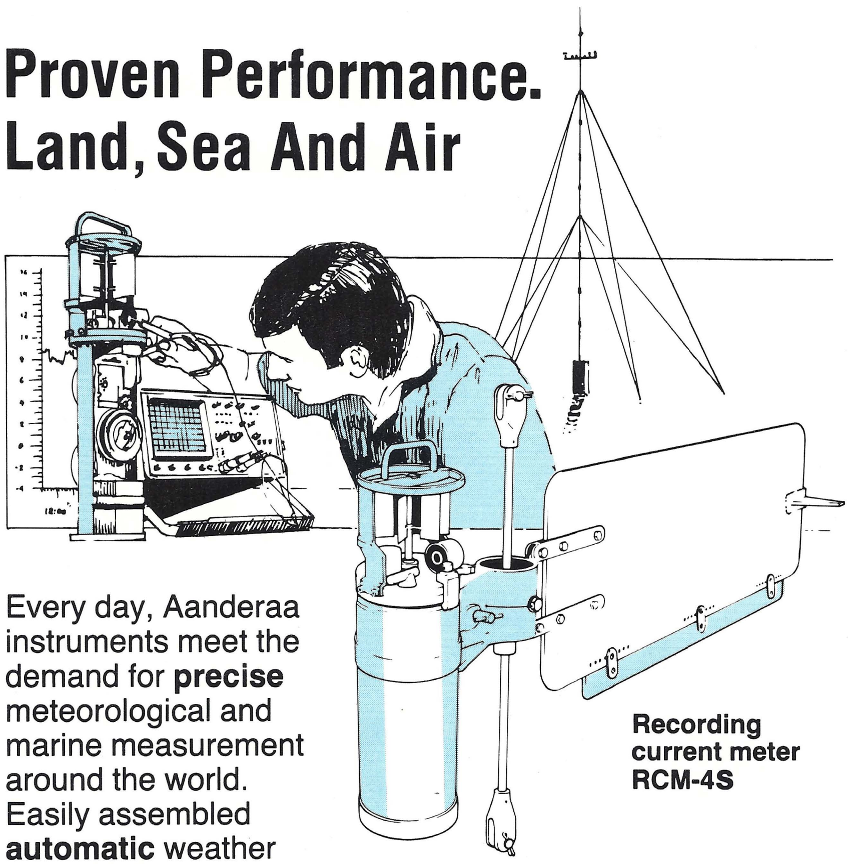
ISSN 0711-5628

Lighthouse

JOURNAL OF THE CANADIAN HYDROGRAPHIC ASSOCIATION

Aanderaa Instruments

Proven Performance.
Land, Sea And Air



Recording
current meter
RCM-4S

Every day, Aanderaa instruments meet the demand for **precise** meteorological and marine measurement around the world. Easily assembled **automatic** weather stations. A wide range of oceanographic instruments. And . . .

Aanderaa's Comprehensive Data Recovery

A reliable . . . accurate and economical retrieval service.
Quality calibration service.
Extensive maintenance facilities.

Call or write:

AANDERAA INSTRUMENTS LTD.
560 Alpha Street, Victoria, B.C. V8Z 1B2
Telephone 386-7783 Telex 049-7390

ARGO: THE BEST RADIO POSITIONING SYSTEM JUST GOT BETTER.

Cubic's ARGO DM-54 has long held first place as the world's best long-range radio positioning system.

But now, we've introduced something even better: the ARGO DM-56.

The new DM-56 is operationally compatible within DM-54 networks. Yet it offers much, much more.

Integral GPS data link

An integral data link lets you send GPS pseudorange corrections for differential positioning to mobile stations for real-time use. This makes lane-count recovery and continual position verification easy. And with this accurate differential GPS position, you can perform calibrations at any time within the operating area, providing for more accurate surveys overall.

Convenient and compact

The DM-56's unique non-volatile memory allows entry and storage of operational parameters prior to dispatching the units to the field. You can also monitor and control the DM-56 from a hand-held ASCII terminal, your host computer, or over a remote radio or telephone communications hook-up after it is in operation. And for added convenience, the DM-56's design includes an automatic self-tuning feature for antenna matching.

All this—and more—in a system that's built into a single compact unit. And since it's based on proven ARGO technology, you can count on the DM-56 for years of precise operation in the toughest working environments.

Call (800) 251-1171 for information.

Or write for specifications on Cubic's new ARGO DM-56 system—making the world's best radio positioning system even better.

CUBIC® PRECISION
A member of the Cubic Corporation family of companies
1308 South Washington Street, P.O. Box 821
Tullahoma, TN 37388, USA

EDITION NO. 35 | LIGHTHOUSE | APRIL, 1987

LIGHTHOUSE

LIGHTHOUSE is published twice yearly by the Canadian Hydrographic Association and is distributed free to its members. Yearly subscription rates for non-members, effective 1988, will be $20 for those who reside in Canada. For all others $25, payable by cheque or money order to the Canadian Hydrographic Association.

All correspondence should be sent to the Editor of **LIGHTHOUSE**, Canadian Hydrographic Association, c/o Bayfield Laboratory for Marine Science and Surveys, 867 Lakeshore Road, P.O. Box 5050, Burlington, Ontario, Canada, L7R 4A6.

Typesetting and production
by
Instructional Media Services
University of Toronto.

Contents

Back Issues of LIGHTHOUSE

Back issues of Lighthouse, Editions 24 through 34, are available at a price of $10.00 (Can.) per copy. Please write to the Editor.

Editor's Notes

The 1987 Canadian Hydrographic Conference

Introduction

From February 17th to 19th, three hundred and twenty-seven delegates from around the world met at the Canadian Hydrographic Conference in Burlington to discuss emerging issues in the field of Hydrography. The Conference was sponsored by the Canadian Hydrographic Service (CHS), Central and Arctic Region, and the Canadian Hydrographic Association (CHA), Central Branch. It featured keynote addresses by Scott Parsons, ADM, Science; Lorraine Petzold, Executive Director of the Ontario Association of Land Surveyors; Steven MacPhee, Director General of the Canadian Hydrographic Service; Jim Bruce, National President of the CHA; and Ross Douglas, Director of Hydrography for Central and Arctic Region.

Technical Program

The theme of the Conference, "Completing the Picture — The Search Continues", focused on the efforts of hydrographers and cartographers to provide mariners with a complete and accurate portrayal of the waters that they must navigate. Twenty papers were presented in eight technical sessions over the three day period. The topics of these sessions ranged from advances in positioning systems, multi transducer sounding systems and airborne hydrography to the use of electronic charts and artificial intelligence in chart making. Other topics included the need for data bases to manage our information and the requirements for hydrographic data in Arctic Marine Transportation and Ocean Mapping of the Continental Shelf.

Exhibits

The conference included commercial exhibits of hydrographic equipment and services from over 20 companies from the hydrographic surveying industry. There were also four non-commercial displays from educational institutions, the CHA and the Canadian Institute of Surveying and Mapping.

Social Events

The social events included a Jar Party, a Dinner Dance, and the Annual CHA Luncheon. Each of the social events was well attended and provided the delegates the opportunity to establish new friendships and renew old acquaintances.

CHA Functions

The CHA held its annual meeting during the Conference at which time the new National President was announced and the LIGHTHOUSE awards were presented. At the Annual CHA Luncheon, Vancouver was selected to host the next conference in 1989.

CHA — National Executive and Annual General Meeting

The national executive and the annual general meeting were both held during the Conference in Burlington.

Jim Bruce, the National President for the past three years, presided over the Executive Meeting. He reported that the CHA finances were generally in good shape, inspite of a loss incurred in the financing of the Colloquim held jointly with the C.P.A. at Banff last year.

An increase in the national dues of $2.00, effective 1988, was approved at the Annual General Meeting.

It was reported that the LIGHTHOUSE was now doing very well with a strong editorial input and the support and contribution being made by the members of the CHA.

The next major Hydrographic Conference will be hosted by Captain Vancouver Branch in March, 1989. This is their first endeavour in this activity and they will greatly appreciate all the help that the other Branches can offer.

At the Annual General meeting, there were about 75 members present. This is the occasion where each of the Branches reports on its activities for the past year. The report of the Quebec Branch was the highlight of the meeting. During 1986, the membership at the Quebec Branch increased from 30 to 70 members. They began the year by incorporating the Branch as a non-profit organization under Quebec law. Armed with this institutional power, they formulated a number of project proposals to be funded through the job creation programme of the federal Department of Manpower and Immigration. Sixteen projects were implemented, providing training and/or employment for nearly 100 persons within a budget of $1.6 million. The Quebec Branch crowned the year by being awarded the Certificate of Merit by the Department of Manpower and Immigration for their achievement in implementing a project at Cap de la Madelaine.

Our congratulations to the Quebec Branch for a magnificent job which has set a shining example for the other Branches of the CHA.

Index of Articles

We are pleased to include in this issue a cummulative index of articles and other material published in LIGHTHOUSE since its inception, in 1969. This index has been produced by the Pacific Branch of CHA and our grateful thanks are due to Mike Bradley, Rikki Chan, 'Sandy' Sandilands, Len Smith, Sharon Thomson and Mike Woods.

Hydrographic Society — U.S. Branch

Captain William Hayes, NOAA (retd), President of Shenandoah Navigation Services, has been elected President of the Hydrographic Society's U.S. Branch in succession to Captain John Hammer, USN.

Other elected officials include Lt. Virginia E. Newell, NOAA (Secretary) and Kenneth F. Burke, DMA (Treasurer).

Jack L. Wallace, who has been Secretary of the Branch since its formation in 1980, has been appointed Executive Secretary-Treasurer.

President's Message

First of all, I would like to take this opportunity to thank all the members of the Canadian Hydrographic Association for participating in the recent elections for the National President. I would especially like to thank those of you who expressed their confidence in me. Ken Clifford deserves thanks for making the election a true competition. I think it speaks well for the whole of the C.H.A. that our election for National President was a competition and not merely an acclamation by disinterested members.

A further vote of thanks to Geof Thompson for arranging the election and for carrying it out so efficiently.

As the new National President of the C.H.A., I have asked myself both before and after being elected, "What do the members want the C.H.A. to be"? I know we have been asking ourselves this question for many years, but I am still not certain that we have an answer. It seems to me that each Branch has its reasons for being and these reasons vary from Branch to Branch across the country. Perhaps it is time that we agree on a National reason!

As the new President, I would like to encourage all Branches to be active, within the broad and basic concepts of the Association, which our constitution says are — 'to advance the technical and professional ability' of association members by:

a) a continued program of study and development,
b) maintaining professional standards of work,
c) fostering a critical interest in hydrography,
d) encouraging interest in the work of related organizations and disciplines.

By endeavouring to focus on these concepts, each Branch will become more a part of the National picture. How each Branch accomplishes this is really up to them, but I think the National President should be a viable part of each Branch and in a sense, a member of each Branch. This can be accomplished by improving the communication between the National President and the executives of each Branch. I hope to improve the communication in the most simplistic and basic way. Some of you may say these items go without saying, but, I think not. Communication will be improved by:

a) writing and answering quickly all correspondence,
b) phoning and returning phone calls
c) Branch distribution of newsletters,
d) articles for Lighthouse that focus on technical and nontechnical, as well as social articles.

We have, by undertaking this very simple process, established lines of communication that work. If we do nothing more than this during the next three years of my term as National President, we will have accomplished a great deal. I will communicate with you and do my part; I invite the Branches to do their part and communicate with the other Branches, as well as myself.

In closing, and on behalf of the National Office of the Canadian Hydrographic Association, I would like to thank the organizers of the recent Conference in Burlington, for a job very well done. The Association members look forward to the proceedings.

COMMUNICATION IS THE BUZZ WORD FOR 1987!

Regards to all,

B.M. Lusk
National President, C.H.A.

High Accuracy Survey Positioning Control

by
Dieter Mackenthun

Abstract

The selection of a positional control system for high accuracy applications will usually rely heavily upon actual user experience. However, independent evaluation of a system's capability, carried out by recognized authoritative bodies or organizations under carefully controlled conditions, can often be of value and interest to potential users.

This paper describes recent surveys with the Atlas POLARFIX system carried out by the Port of Hamburg. It also briefly describes independent testing of the POLARFIX to confirm accuracy.

Introduction

Consistent and verifiable high accuracy positional control is essential for applications such as surveying and dredging in approach channels, rivers and harbor environs. These requirements are particularly self-evident at the Port of Hamburg, West Germany, which has been an important proving ground for the continuing development of the Krupp Atlas Elektronik POLARFIX range-azimuth laser positioning system and associated hydrographic survey equipment.

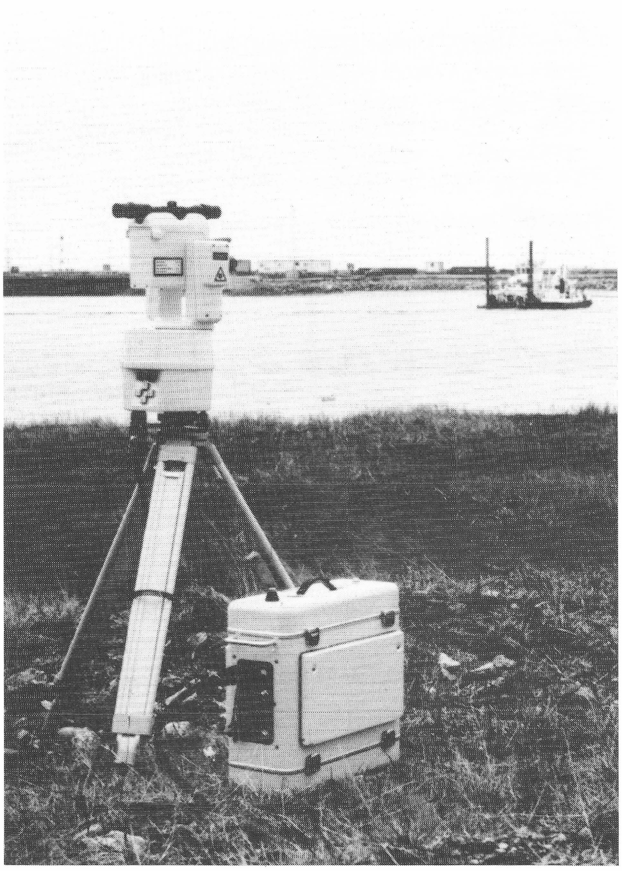


Fig. 1: POLARFIX laser positioning of dredger.

Situated in the Elbe Estuary, the Port is subject to continuous sedimentation and shoaling. Approximately two million cubic meters of mixed material, consisting of variable proportions of mud and sand, is dredged annually from the main shipping channel and harbor areas. As a result of this ongoing requirement, the Port Authority was among the first to adopt a digital hydrographic sweeping system for pre-and-post-dredging survey operations.

Total survey area covered is some 40 square kilometers including a 50km stretch of the River Elbe. In all, between 50% and 60% of the area is comprehensively surveyed twice yearly while critical harbor basin approaches receive more frequent attention.

Given that such a large area is comprehensively surveyed several times a year for shoal detection, there is an understandable premium on optimum operational efficiency. This is met firstly by swathing in preference to cross-profiling, thereby reducing actual survey time and averting costly neglect of a sector which might otherwise have to be resurveyed at a later stage. At the same time, the approach also provides a much higher resolution of the bottom structure. Overall efficiency is further enhanced by accurate positioning to avoid any time-consuming overlap of survey runs. With the recent commissioning of a POLARFIX system and an automated ATLAS SUSY 30 survey processor for navigation control, the Port is now able to more rapidly survey the total area under its control.

Operation

The Port's own survey vessel, "DEEPENSCHRIEWER II", is equipped with an Atlas BOMA 20 bottom mapping system which produces scale recordings of local morphology as stratum areas with coded grey gradations. Consisting of a series of transducers mounted in both the hull and 15 meter hydraulic booms on either side of the vessel, this system can provide a gapless survey swath of approximately 37 meters. The boom design provides acceptable average vessel speeds of around four knots with good horizontal stability.

Overall positional control is maintained by the Atlas POLARFIX laser system with automatic tracking, interfaced to an Atlas DESO 20 dual-channel sounder and an Atlas SUSY 30 survey navigation and data processor. The SUSY configuration itself provides very precise track line navigation while also producing correlated depth and position information to both the swath (bottom) recorder and an A-0 size track plotter.

Considerations which originally led to the adoption of POLARFIX were largely governed by difficulties previously encountered with radio positioning systems. All were susceptible to unwanted reflections in a largely built-up survey area, either by electromagnetic or acoustic disturbances.

Moreover, relatively high logistical costs were associated with continuous siting and re-siting of remote stations in order to secure adequate survey coverage. Surveying a chart length of 2.8 kilometers, for example, demanded a minimum of four shore stations for the realization of an acceptable intersection angle cut. It was found that no radio system could register a required positional accuracy of plus or minus two meters over more than half the total survey area.

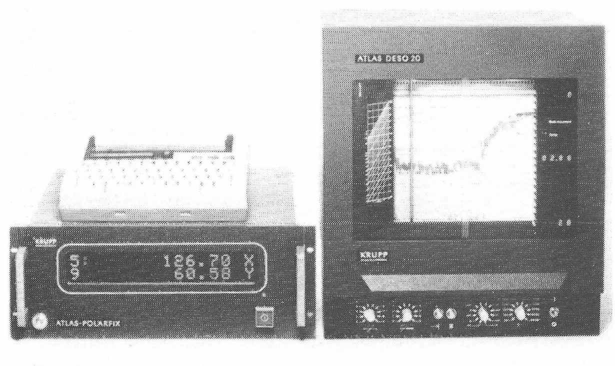


Fig. 2: POLARFIX ship station with survey echosounder.

The POLARFIX range/azimuth system was chosen after exhaustive tests of alternative positioning methods in the built up area of the port. Only the POLARFIX virtually eliminated traditional problems including propagation anomalies, microwave interference and signal reflection. The single station operation with consistant accuracy substantially reduced the usual concerns of site geometry and resulting logistics costs. Built in dead reckoning and search functions provided true automatic tracking even where obstructions were unavoidable.

According to Port survey authorities, the POLARFIX has met all expectations and has already contributed to substantial improvements in quality and output of surveys while meeting and/or exceeding the high order uniform accuracy requirement. Individual survey runs are now completed in straight swaths, or longitudinal profiles, with covered strips matching each other gaplessly. With continuous fixes updated every half second, positional errors are minimized while a predictive filter provides extrapolated values up to ten times per second. Moreover, since the maintenance of very precise survey lines ensures that the vessel's transducer boom neither dip nor rise in the water, errors in depth are also reduced to a minimum.

Correlation of fluctuating water levels is also possible by use of the new PLM 1170 level meter, which has already proved exceptionally useful at the Port of Hamburg where there is a normal tide range of 3.4 meters. From a portable pressure gauge in the water, connected by cable to the shore-based POLARFIX STATION, data is automatically relayed to the shipborne telemetry receiver at pre-selected intervals. The swath system is thus provided with a true depth correction factor for adjustment to the required datum. Accuracy of the meter is ±1cm.

System Enhancements

Experience of the POLARFIX-SUSY 30 configuration at Hamburg has led to the recent development of POLAR SUSY, or Polar Survey System, with which integral survey operations can be carried out independently of a host computer. POLARFIX's customary shipborne UHF telemetry receiver has been upgraded to a fully-fledged 19-inch rack survey processor capable of directly driving a combination of navigation display, plotter and mass data storage peripherals.

Thus, pre-plot, on-line data storage and navigational functions can all be handled simultaneously by the new PSP 1026 processor, using standard software at no additional cost beyond that required for peripherals. At the same time, a DESO 20 sounder can also be connected for outputting all depth values from two separate channels. Up to 12 pairs of values per second are available. Depth and POLARFIX position can be synchronized for logging either by mass storage device, external computer or low-cost printer terminal connected to the PSP 1026. Peripherals can also be used to input instructions directly to POLARFIX such as a request for the conversion of range-azimuth data into rectangular coordinates.

Alternatively, POLAR SUSY is also designed to operate with the new DESO 25, a precision multi-purpose research sounder which can be operated either as a single or dual-channel transmitting echosounder, a receive only pinger sounder, or as a remote recorder.

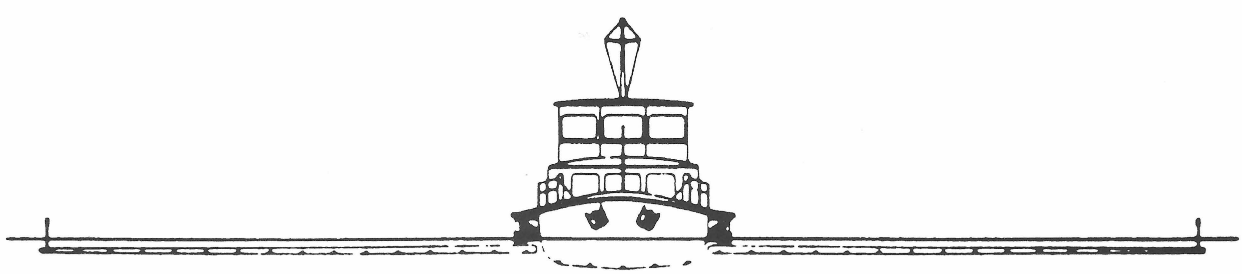
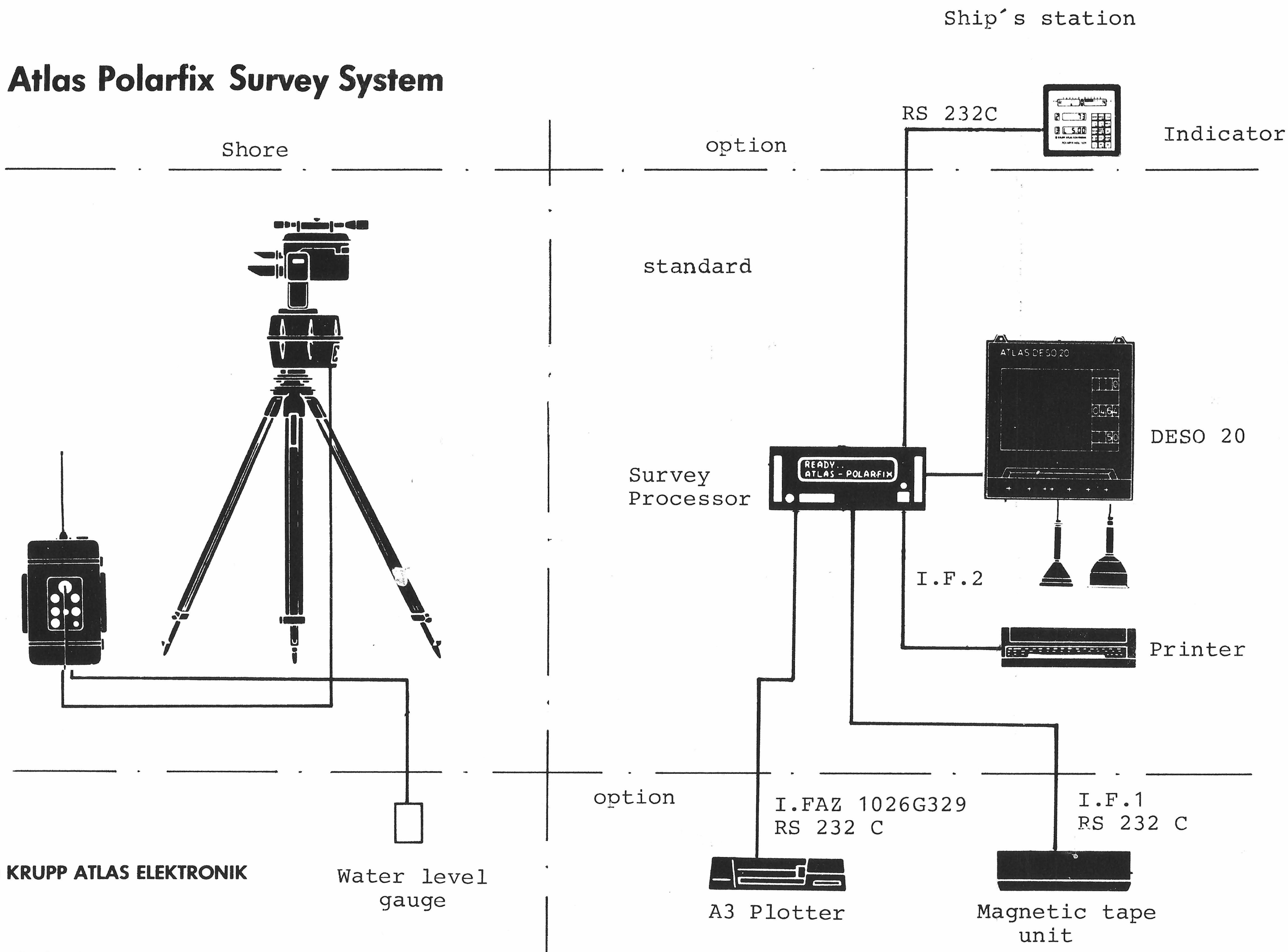


Fig. 3: Swath transducer booms.

Atlas Polarfix Survey System



KRUPP ATLAS ELEKTRONIK

Fig. 4: Level gauge for continuous monitoring of tide.

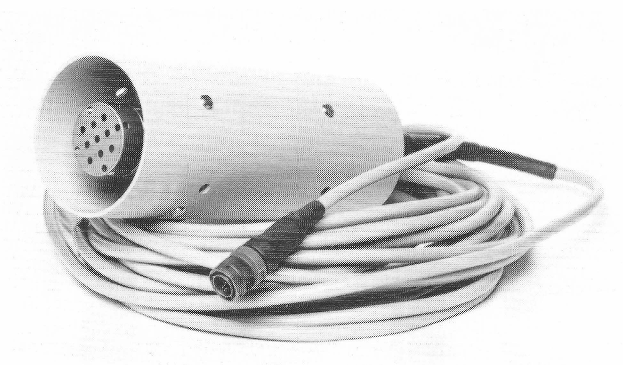


Fig. 5: Antonomous POLARFIX survey system.

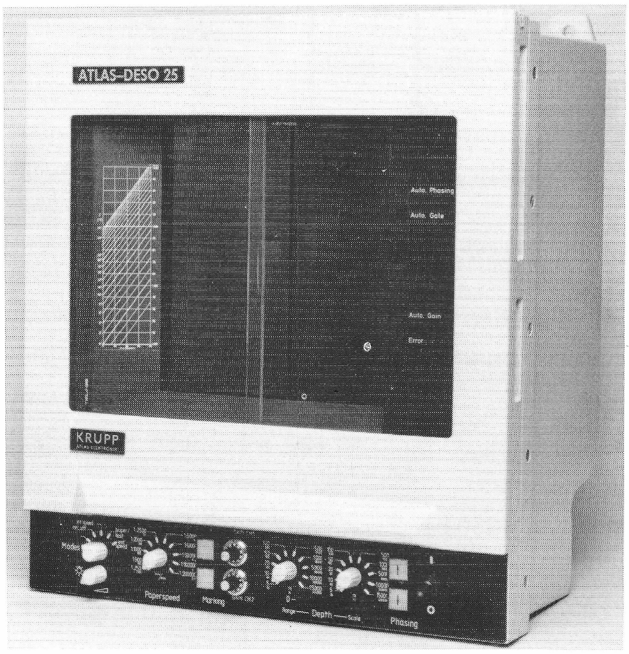


Fig. 6: Sediment and survey sounder DESO 25.

Incorporating built-in digitizer facilities, the survey or sedimentology version is a novel three-channel recorder. It presents discrimination between silt and solid bottom as a general echogram while also providing a selectable bottom expansion recording with graphic indication of any obstruction buried in bottom layers. Extensive remote control functions include scale select, speed of paper, water sound velocity, time synchronisation, event control and annotation. The DESO 25 has high resolution (0.125mm) thermosensitive recording with 20cm wide paper. Phasing and gain can be controlled manually or automatically.

Accuracy

The manufacturer's specifications for the POLARFIX is ±0.5m, ±0.1m per 1,000m of measured range. Normal operating range is approximately 5,000m, limited to about 1.5 X visibility in fog.

Results of the user community in Europe, North America and other areas indicate performance equal to or better than these nominal specifications.

A series of recent independent tests in the U.S. and Norway were aimed at evaluating the precise dynamic and static accuracies of POLARFIX itself. Observations by the Applied Physics Laboratory of Johns Hopkins University on behalf of the U.S. Navy confirmed the claimed accuracies at short to medium operating distances.

At a nominal range of 1180m, mean error was 0.05m in range and -0.002 degree in bearing. Standard deviation was ±0.14m in range and ±0.010 in bearing. During 66 trial runs, 1231 measurements were made at speeds from approximately 1.75 to 8.75 knots. Combined mean error was 0.078m and combined standard deviation ±0.248m.

At NATO's Naval Forces Sensors and Weapons Accuracy Check Station (FORACS) near Stavanger in Norway, dynamic tests to determine position of the naval frigate, BERGEN, disclosed measurement accuracies of ±0.5m in the X and ±0.35m in the Y direction. These correspond to an RMS error rate of 0.6m at a distance of 4km. Long range tests showed 9.9km range as accessible in clear weather conditions.

Summary

As indicated by the operations at the Port of Hamburg, the Krupp Atlas POLARFIX is an accurate, reliable positioning system for short/medium range requirements. Reports from other operators around the world and tests by independent authorities confirm this experience.

The new POLAR/SUSY, DESO 25 and tide gauge options provide further versatility and enhance the system's value.

Approximately 20 POLARFIX units are already operating in North America, evenly divided between Canada and the United States. Canadian operators include Public Works Canada, Canadian Hydrographic Service, Canadian Coast Guard and Department of National Defense.

An Application of Acoustic Core Analysis

by
Michael R. Tarbotton and Douglas S. Murphy

**Marine Directorate, Ottawa.

Introduction

In 1967, Swan Wooster Engineering was commissioned by the National Harbours Board to study possible locations in the vicinity of Vancouver for a new coal loading port. The site selected was on the south end of Roberts Bank, a drying bank located some 30 km south of Vancouver, just north of the U.S.A./Canada border.

The original site, built in 1968-69, comprised a 4500 m long causeway across the flats, out to a 22 hectare storage and terminal area, all built from reclaimed dredge spoil.

In 1980, following 5 years of study, including hearings by the Environmental Assessment and Review Panel (EARP), the National Harbours Board (NHB) decided to proceed with a major expansion of the port facilities at Roberts Bank. Swan Wooster was retained by the NHB as project managers for the design and construction supervision of three new terminal sites, totalling 87 hectares of new terminal area, and a tripling of the causeway width to accommodate future rail and vehicle access to the terminals. Included in the expansion was the dredging of some 14 million cubic meters of material, to form a new harbour and turning area for ships up to 220,000 DWT. The fill required for the new terminal and causeway was over 8.5 million cubic metres, all of which was to be hydraulically placed by the dredgers. Dredging started in September 1981 and was completed in July 1983. Due to the environmental sensitivity of the deltaic site, dredging was interrupted during the most biologically productive period of 1982.

Figure 1 shows the location and scope of the project, while Figure 2 presents an aerial view of the nearly completed site, looking north-eastwards.

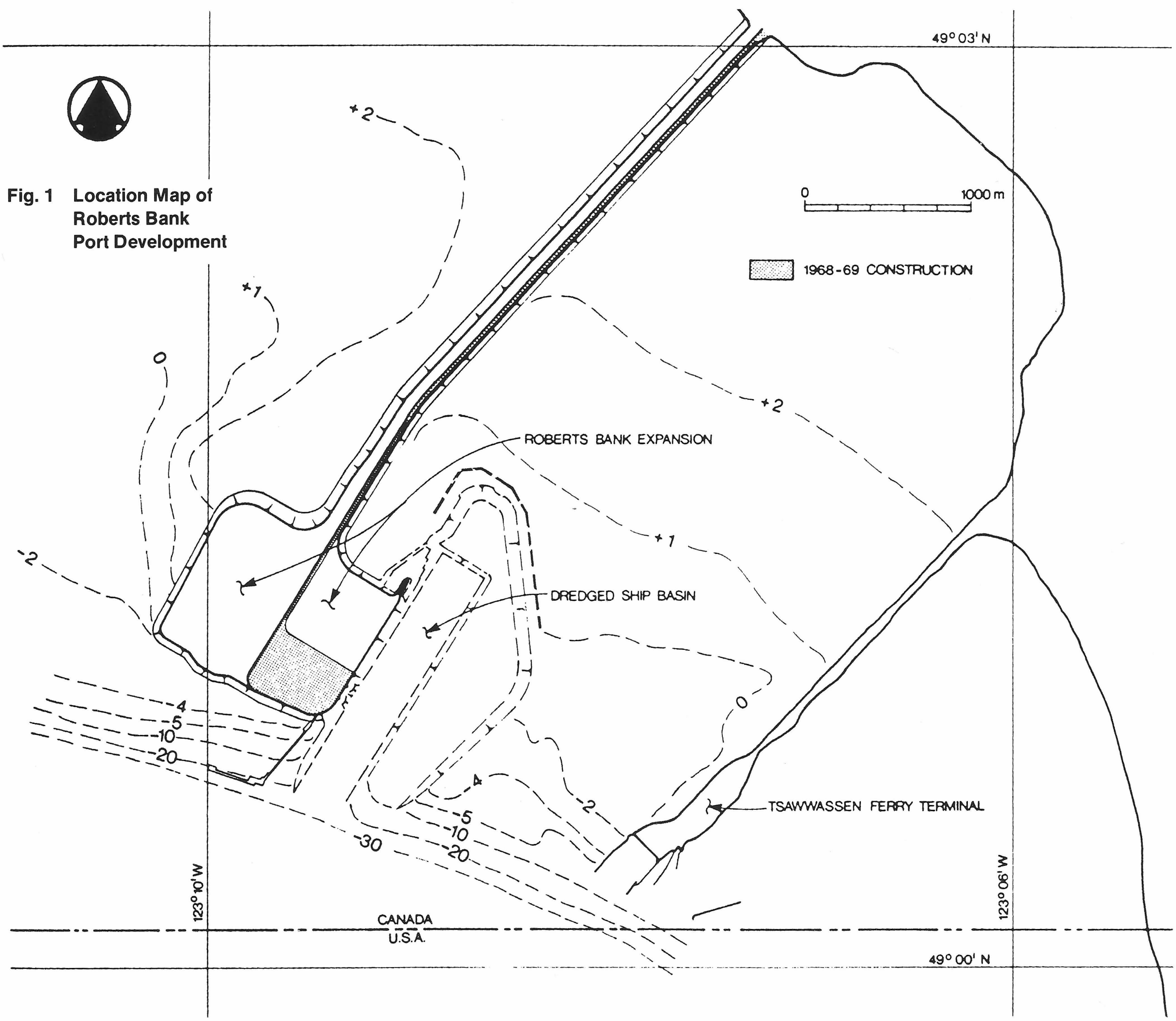


Fig. 1 Location Map of Roberts Bank Port Development

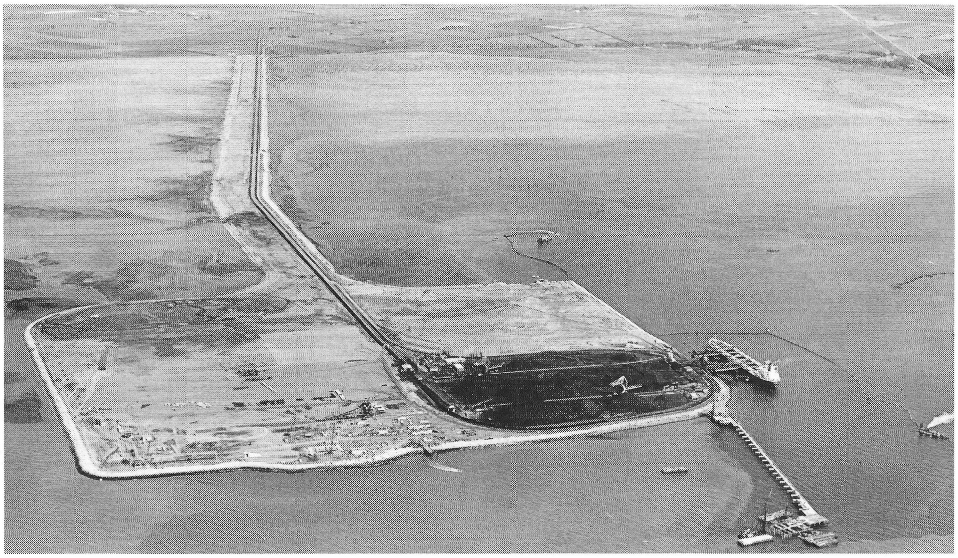


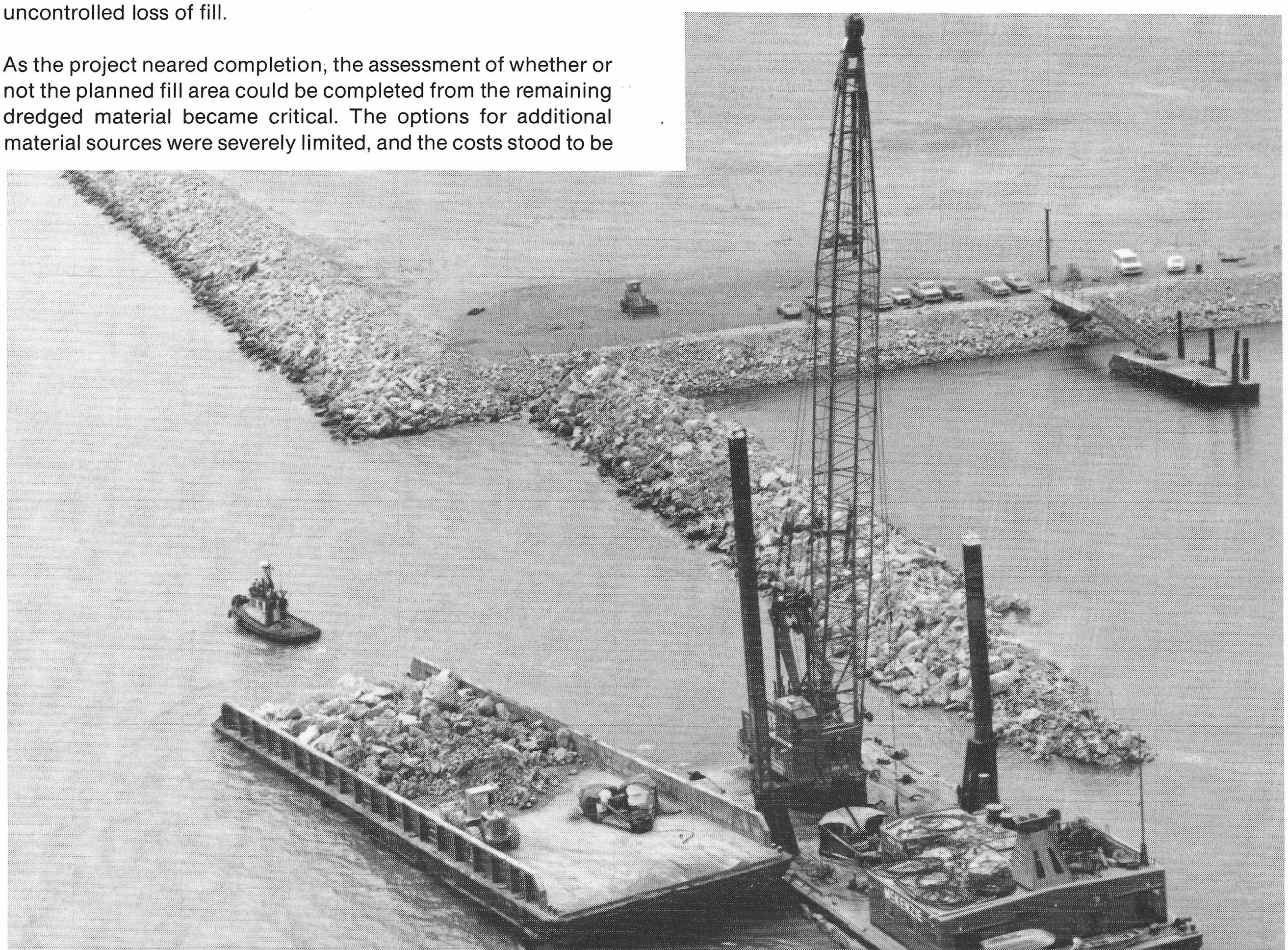
Figure 2
An aerial view of the site in April 1983, looking north-eastwards. The dredgers "Sceptre-Fraser" and "King Edward" are shown in the right centre and lower right. Levees are visible in the northern corner of the site and on the left side of the causeway. The new loading dock can be seen in the lower centre of the photo. The 1968-69 construction included the coal stockpile area and causeway with twin rail lines, which show dark on the photo. (Photo by Allen Aerial Photos, courtesy Dillingham Construction.)

2. Construction

As the dredging progressed, it became apparent that the original soil information did not forecast the large variability of the material type within the planned dredging area. Although over 30 boreholes had been drilled in the dredge basin during the design phase, it had been discovered that the material in the basin varied radically over short distances — that it could change from sand to silt over 50 m or less. In many instances, the material changed completely across the width of the dredge cut, resulting in considerable variability in fill quality of the reclamation site and uncontrolled loss of fill.

As the project neared completion, the assessment of whether or not the planned fill area could be completed from the remaining dredged material became critical. The options for additional material sources were severely limited, and the costs stood to be prohibitive owing to possible third season mobilization costs. The desire to complete the program without a second stoppage during the productive season became an added incentive to ensure that the required balance of cut and fill could be achieved.

It was recognized that additional soil information was required in order to permit the assessment of the quality of dredge material remaining and to determine the likelihood of completing the 500,000 cubic metres of fill from the remaining 2,00,000 cubic metres of dredge material, and to identify further borrow areas if required.



3. Sub-Bottom Surveys

Several techniques for sub-bottom soil identification were considered to obtain a wide coverage of material conditions within the basin.

Traditional seismic profiling techniques, which are based on the assumption of more or less even and homogeneous sub-bottom layers, had not proved successful in similar bottom conditions to those at Roberts Bank on previous projects.

Additional boreholes could have been drilled on a close grid of not more than 50 m spacing. However, the estimated cost of C$7500 per hole for the 100 additional holes required, made coring look decidely uneconomical. An alternate technique was therefore sought.

Through professional contacts, Swan Wooster learned of the Caulfield Engineering method of Acoustic Core Analysis. The method which was first used to locate sand borrow areas for artificial islands in the Beaufort Sea had been developed over a period of 10 years. Although it had a rather limited proven field record at the time, an extremely attractive two-part field program was developed which made it well worth trying. A test program could be run at cost to determine whether the method could successfully identify layers in the vicinity of previous boreholes; if so, a full scale program would cover the entire dredge area on a 50 m x 50 m grid. At an estimated total cost of C$35,000 for the full survey and partial computer analysis, and a further C$8800 for survey assistance and engineering assessment, this method provided the most cost effective alternative.

Prior to embarking on the survey, a number of limitations of the system were identified.

The first limit to data acquisition was that, due to the echoing of acoustic impulses between the sea floor and the water surface, only those layers which were within a single multiple of the water depth beneath the bottom could be identified readily. Past this depth, filtering of the return signal would be necessary to eliminate harmonics of the primary signal. Since much of the basin had been at least partially dredged, this was not too serious a drawback.

A second limitation was that the boundaries between successive layers could be determined only to within plus or minus 0.4 m due to an averaging of the return signal over one wavelength, and the measurement time step.

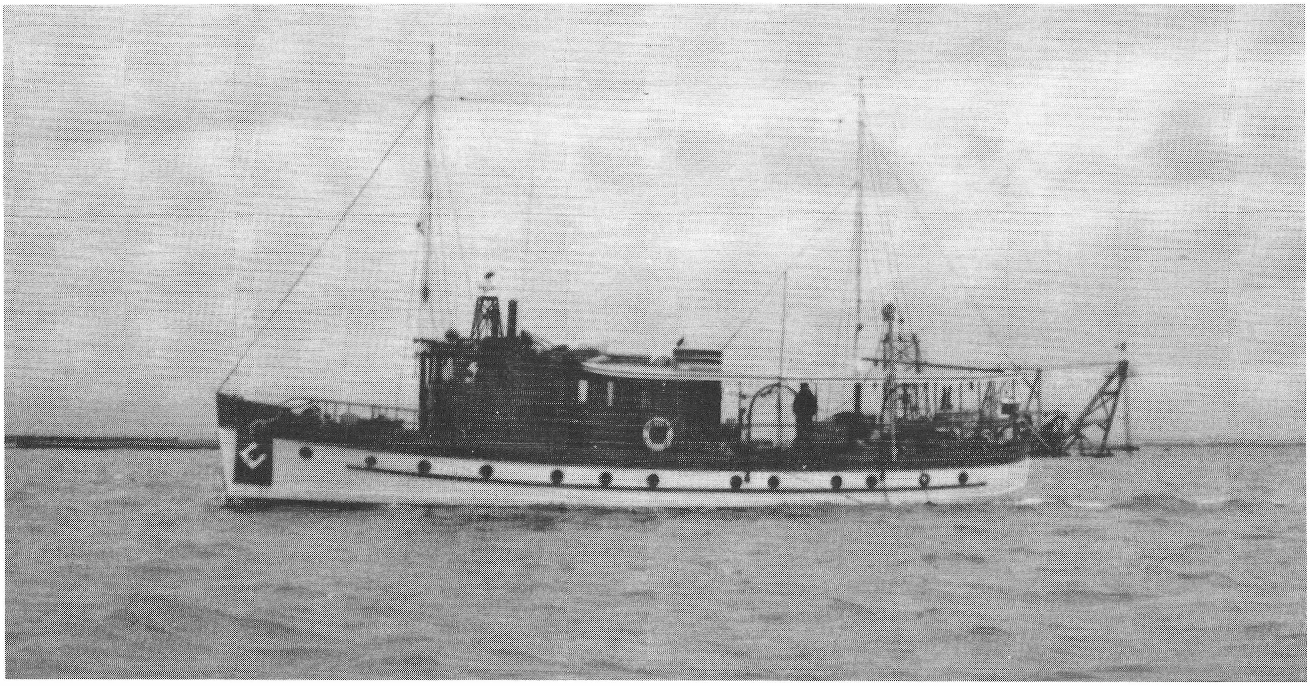
A final limitation of the system lay in its assumption that the acoustic impedance obtained for each layer bore a direct relationship to the mean grain size of the layer. Calibration to previous local boreholes confirmed this relationship in general, but some areas were found where variation in situ densities led to incorrect grain size determination. However, these deviations were directly attributable to previous disturbance of the layers and/or infill during the dredging program. For the majority of the basin area, the system was verified time and again by direct comparison to borehole data.

4. Survey Details

Briefly the survey equipment consists of an E.G. & G. "Boomer" as a sound wave source, with a linear array of receivers floating beside the source. The acoustic return signal is then amplified, digitized and recorded on magnetic tape and simultaneously charted by an on-line EPC graphic recorder. Fix marks are shown on the EPC chart to provide horizontal scale. For some of the shallow water areas adjacent to the dredge basin, an ORE "Pinger" and receiver were used for the acoustic signal.

Positioning of the survey equipment was accomplished with the Racal-Decca Autocarta system, owned and operated by Swan Wooster Engineering for bathymetric surveys. The system takes up to four microwave ranges from land stations and computes the position. This was tied into the sub-bottom profiling equipment to provide time and distance fixes for charting purposes.

The EPC records were tide corrected and used to produce transverse sections of the dredge basin. Material types were assessed for the layers of the sections based on intermittent numerical analyses performed by Caulfield Engineering of Calgary, Alberta. (The description of the analysis may be found in references 1 and 2). As a verification of material identification, layer boundaries and types were followed along both transverse and longitudinal lines.



5. Design

Having thus established the material content and extent of the layers within each of the remaining dredge cuts, there remained only the task of estimating levee fill quantities from in situ quantities in the dredge basin.

First of all, the banks of material remaining were assigned to a proposed dredge cut, in order to establish an overall average material quality for each cut. This quality was expressed as a percentage of silt overall, based on established grain size from the Acoustic Core Analysis, and a silt content for each mean grain size as determined by borehole data. For our purposes, silt was defined as material passing a #200 sieve, .075 mm diameter. The volume of cut was then converted to a levee volume using the relationship of losses to silt content shown in Figure 3. Although somewhat conservative, this relationship was based on tests made at the discharge pipe, levee measurements and dredge logs over the course of the project, and it reflected average levee management procedures. Slightly lower losses could be obtained with careful or special levee management, at the expense of increased silt content in the fill.

The net result of the analysis was that the total projected additional fill volume that would be produced up to the end of the dredging job amounted to only 430,000 cubic metres for a shortfall of 70,000 cubic metres. However, as this shortfall represented only 3½ percent of the total dredge volume, and since the loss assumptions were recognized as being somewhat conservative, it was felt that the fill could be completed by exercising careful levee control. As a precautionary measure, a large pocket of medium to coarse sand was located, and verified by further computer analysis, as being of sufficient quality and quantity to complete the fill.

6. Method Success

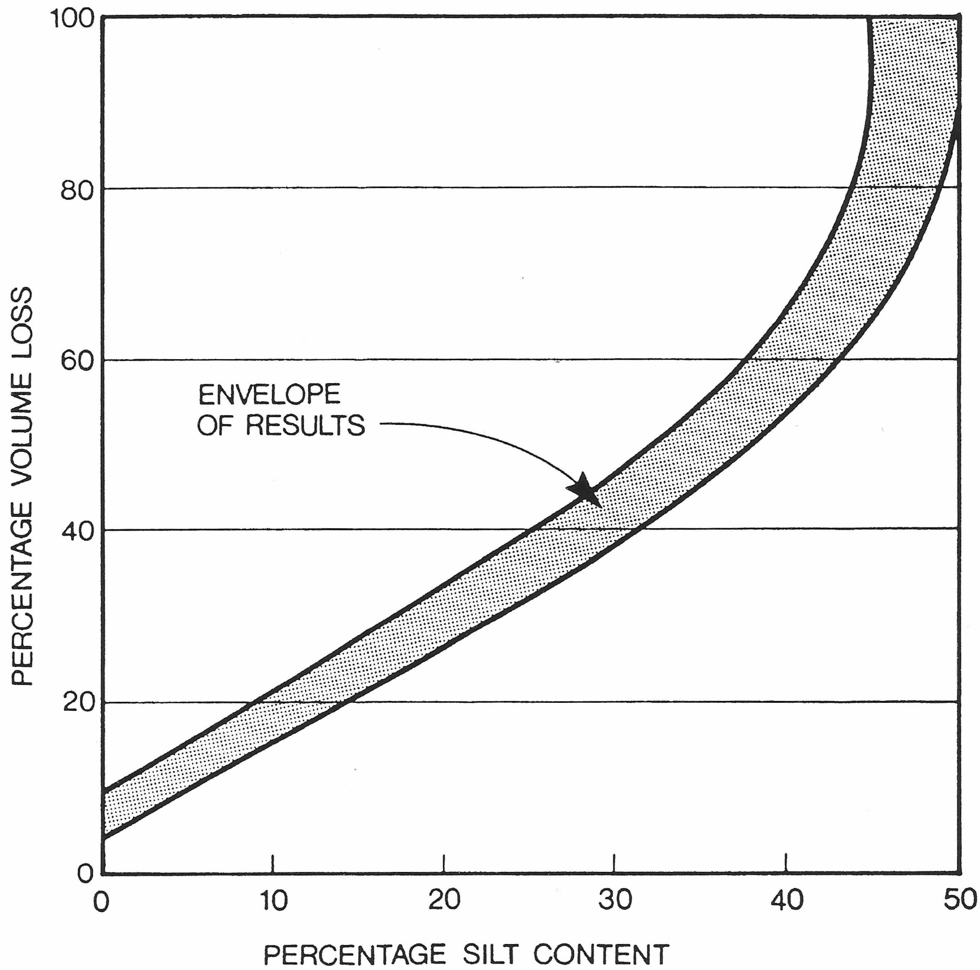
As the dredging progressed, the actual fill obtained from each dredge cut was estimated by levee survey, and this volume was compared to the predicted volume. Actual dredge volumes, established by hydrographic survey, agreed closely with the estimated cut volumes.

Of the fourteen remaining dredge areas identified in the January 1983 acoustic survey, ten yielded levee volumes within plus or minus 10 percent of the estimated volume, mostly on the higher side.

Two smaller cuts (under 70,000 cubic metres each) yielded losses 20 percent higher than expected, but this may be attributable to

FIGURE 3

VOLUME LOST THROUGH SPILL AS FUNCTION OF SILT CONTENT OF DREDGE CUT



the fact that both lay at very steep slopes (2.5:1 and 4:1, respectively), and the signal loss during the survey was high. This may have yielded somewhat erroneous results, because the cuts were so small and sloped.

Two large cuts, totalling 700,000 cubic metres had losses of 10 to 20 percent less than estimated. This was one of the few occasions on which the engineer may be gratified to find himself in error. In these areas, the very small depth of cut was the sources of the discrepancy. As mentioned previously, the tolerance of layer boundary identification was plus or minus 0.4 m. In many of the areas, this tolerance represented up to 20 percent of the cut depth. Consequently, it is considered that the error in the volume estimate was related to an overestimate of the proportion of the silt material in the dredge cut.

In addition to the above discrepancies, it was noted that the top half metre (1½ feet) of material in the basin, which was in all cases identified by acoustic core analysis as sandy silt or worse, was often much better than expected. This was explained by Dr. David Caulfield, who devised the analysis method, as being the result of an averaging effect of acoustic impedance values over the preceding one wavelength of pulse. Since the adjacent layer was water rather than sediment, the acoustic impedance, and hence grain size estimate, were considerably reduced. In order to correctly identify the surface layers, a higher frequency signal could have been employed, but this would also have effected the depth of penetration.

The result of the dredging program forecast was that the fill was completed with 100,000 cubic metres of dredging remaining. This meant that the actual average dredging losses were 74%, as compared to the 78% predicted. This margin of accuracy was well within the recognized limits of the prediction, since the loss relationship to silt content alone was only accurate to plus or minus 10%. Thus the technique could be considered a success.

7. Technique Development and Future Use

As a result of Swan Wooster's work at Roberts Bank, a new tool for engineering assessment of borrow material has been identified. The acoustic core analysis technique may be applied in many areas for which a standard borehole program proves too costly or otherwise inadequate.

The unusual sediment layering of the Roberts Bank delta also provided an invaluable calibration case for further development of the acoustic core technique. This work to date includes: the addition of a function in the analysis to identify fine material underlying coarse sediment; a provision in the plotting program to produce colour-coded cross-sections of any survey line, in order to reduce the time taken to produce these manually and a more rapid solution technique for the actual core analysis, which has dramatically reduced the post-survey computing costs.

In recognition of the potential of acoustic core analysis, the U.S. Army Corps of Engineers has recently acquired the rights to utilize the technique as a standard for sub-bottom survey. This will ensure wide usage in the future.

8. Recommendations

Acoustic core analysis has demonstrated great versatility, but should be used only after an assessment of its strengths and weaknesses. Although this investigative technique has strong elements in its favour, the following points should be considered by potential users of the method:

(a) It is strongly recommended that some borehole or test pit data be available in the vicinity of the survey area for calibration of the analysis results. This will ensure that no unusual local effect will cause undue misinterpretation of the results.

(b) Another major point to consider is that the technique is intended for shallow depth application. If information is required 30 metres below the sea bed in a water depth of 6 metres, poor quality results may be expected. In like manner, extremely dense material may result in virtually no signal penetration regardless of the water depth. In either of these circumstances, an extensive borehole or seismic program may provide the only viable alternatives.

(c) A strong factor in favour of acoustic core analysis is its low cost and wide coverage. The survey equipment is very portable, and can be installed in a local vessel. This is a great advantage in relatively remote areas, where drill rig mobilization costs would be high.

9. Conclusions

The judicious application of the sub-bottom survey data resulted in major benefits to the project engineering of the Roberts Bank dredging work.

Firstly, it assured the project managers that the fill could be mostly if not totally completed within the contract dredging period. It also identified the best possible auxilliary material source for any possible extra dredging.

Secondly, had the indicated preference of environmental control agencies to avoid dredging during the biologically active period not necessitated a rush to complete the project in the last five months, the information obtained through the acoustic survey could have permitted a modification to the dredging schedule. This would have allowed the best use of all the coarser material first, to complete the required fill, and then the large volumes of extremely poor material could have been pumped to deep water disposal.

The acoustic core analysis technique has shown itself to be extremely successful at Robert's Bank, in a highly variable bottom material, where shallow depths were not a significant problem, and some borehole data were available. Such an application for acoustic core analysis provides the ideal case for cost effectiveness, as an extremely expensive borehole program offers the only viable alternative.

The authors would like to thank the National Harbours Board (now the Vancouver Port Corporation) and Caulfield Engineering for their assistance and cooperation in the preparation of this paper.

References

1. Caulfield, D.D. and Y.C. Yim: "Prediction of Shallow Sub-Bottom Sediment Acoustic Impedance Estimating Absorption and Other Losses", Proc. Canadian Society of Exploration Geophysicists, April 5-7, 1982.
2. Caulfield, D.D., Y. Yim and T. McGee: "Application of the Auto-correlation Function for Layer Identification in Shallow Seismics", Proc. Canadian Society of Exploration Geophysicists, April 26-28, 1983.
3. Caulfield, D.D., private communications, 1983-4.
4. Johansen, C. and O. Birkelund; "Expansion Plans for the Roberts Bank Offshore Island Port Facilities", Proc. WODCON IX, Oct. 29-31, 1980.
5. Tarbotton, M.R.; "Roberts Bank Construction", Coastal Research and Project Workshop, ACROSES, March 26, 1982.

Five Years of Scanning Sonar Experience in the Beaufort

by
Hugh R. Stewart

Introduction

During the past five years, Gulf Canada has utilized sector scanning and profiling sonars for a wide variety of purposes in support of its exploration activities. The main purpose of this paper is to demonstrate the versatility of these instruments. Field experience with these sonars are documented together with some examples of the results.

It is hoped that this review will encourage other potential users to take advantage of the capability of these precision tools, while simultaneously making them aware of essential deployment procedures and some limitations of the system.

Several sonars are available on the market. However, Gulf Canada, through its various survey support companies, has almost exclusively used the Mesotech sonars. Detailed specifications are available from the Manufacturer, while a brief technical description is provided in the following paragraphs.

System Principles and Description

Profiling and imaging sonar systems employ a measuring principle similar to that used in radar. A rotating transducer emitting a high frequency conical or fan shaped beam, receives discrete echo returns from individual reflectors. Depending on the anticipated application, transducers with different beam patterns and different frequencies can be employed to give the desired display and the required range. The results are also affected by the pulse length, signal beam width, sweep scan density, acoustic attenuation and reflectivity of the target. Distortions can occur due to velocity variations resulting from thermoclines and density discontinuities. The need for a stable, position referenced, platform although obvious is sometimes difficult to achieve, thus affecting the accuracy of the end product. Ref. 1 and 2 provide the theoretical and design background to this technology.

Figure 1 illustrates the various components which can be interfaced to the most recent Mesotech sonar head, the 971. A min-

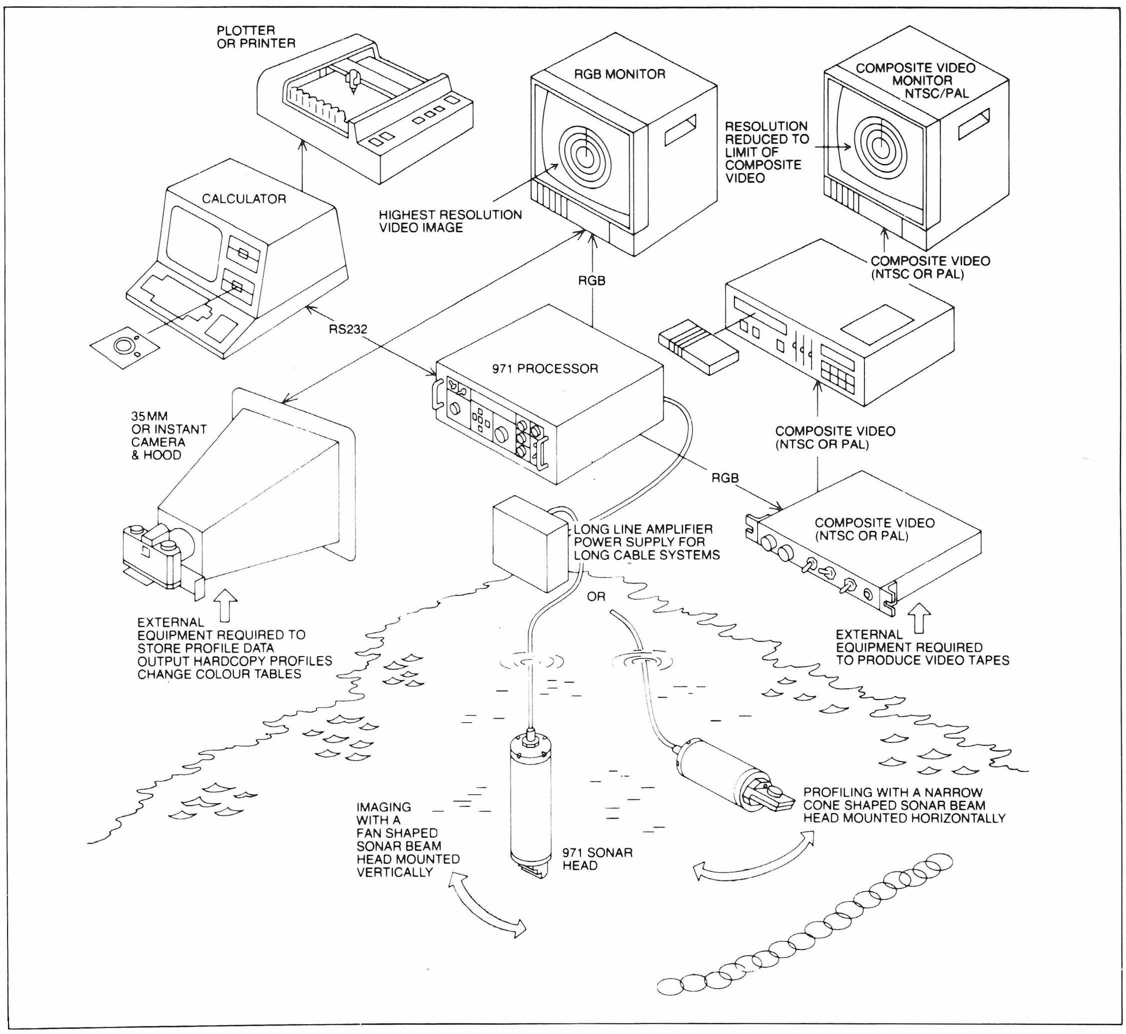


FIGURE 1
MESOTECH 971 SONAR SYSTEM COMPONENT

imum configuration would be the sonar head and cable, the processor and a visual display unit. If any data processing is involved, as is often the case, a computer is interfaced to the processor. Additional features such as a plotter, 35 mm camera or a video recorder are possible. The **figure** does not illustrate the many types of support frames necessary for sonar head deployment.

Beaufort Activities

From a historical perspective, ice keel profiling was the first activity performed by Gulf using sector scanning sonars in the Beaufort Sea. In 1983 the conical drilling unit, the **Kulluk**, commenced exploration drilling and utilized these scanning sonars for both initial wellsite positioning and later reentry purposes. Search and retrieval operations for anchors and a template were also facilitated using scanning sonar technology. A remotely operated vehicle (R.O.V.) located a wellhead and blow out preventor (B.O.P.) during some maintenance operations with the aid of a scanning sonar. In 1984, the **Molikpaq**, a bottom founded drilling structure was mobilized into the Beaufort Sea. Scanning sonar has been deployed during rig positioning on the underwater sand berm, for monitoring the infilling and dredge out of the sand core and in evaluating the adequacy of the some toe protection. Most recently, during 1986, real time observation of a 24′ (7.3 m) diameter caisson installation on the seafloor, as a retained gloryhole, was performed with a profiling sonar. The scope of uses for scanning sonar are further described below.

Ice Feature and Seafloor Profiling

The first under-ice project was primarily of a scientific nature while the purpose of the subsequent two surveys was predominantly for engineering considerations.

Following the under-ice survey work performed by Offshore Survey and Positioning Services (OSPS) for the Polar Gas pipeline in 1978-1980, (Ref. 3), Gulf Canada undertook several under-ice surveys. Both the underside of ice features and the seafloor were measured. The first field operation was based at Sachs Harbour on Banks Island in 1982 and involved the measurement of large ice-pressure ridges. The primary objective was to determine the ice thickness distribution of typical and extreme ice floes.

The use of profiling sonar enabled the shape of the ice features to be measured rather than just spot thicknesses achieved with conventional drilling. Both the 952 and 961 Mesotech sonars were used with adapters to direct the sonar towards the underside of the ice. A more time consuming deployment of the heavier and larger 952 was compensated for by its increased range.

In analyzing the data, it was essential to cross reference it to the drilled manual data, otherwise some degree of spurious tilt was introduced into the data, although the shape remained undistorted. At this early stage it was anticipated that the accuracy of the acoustic profiles were well within 25 cm, particularly if reasonable overlap was maintained with a maximum of horizontal range of unduplicated measurements of 50 m.

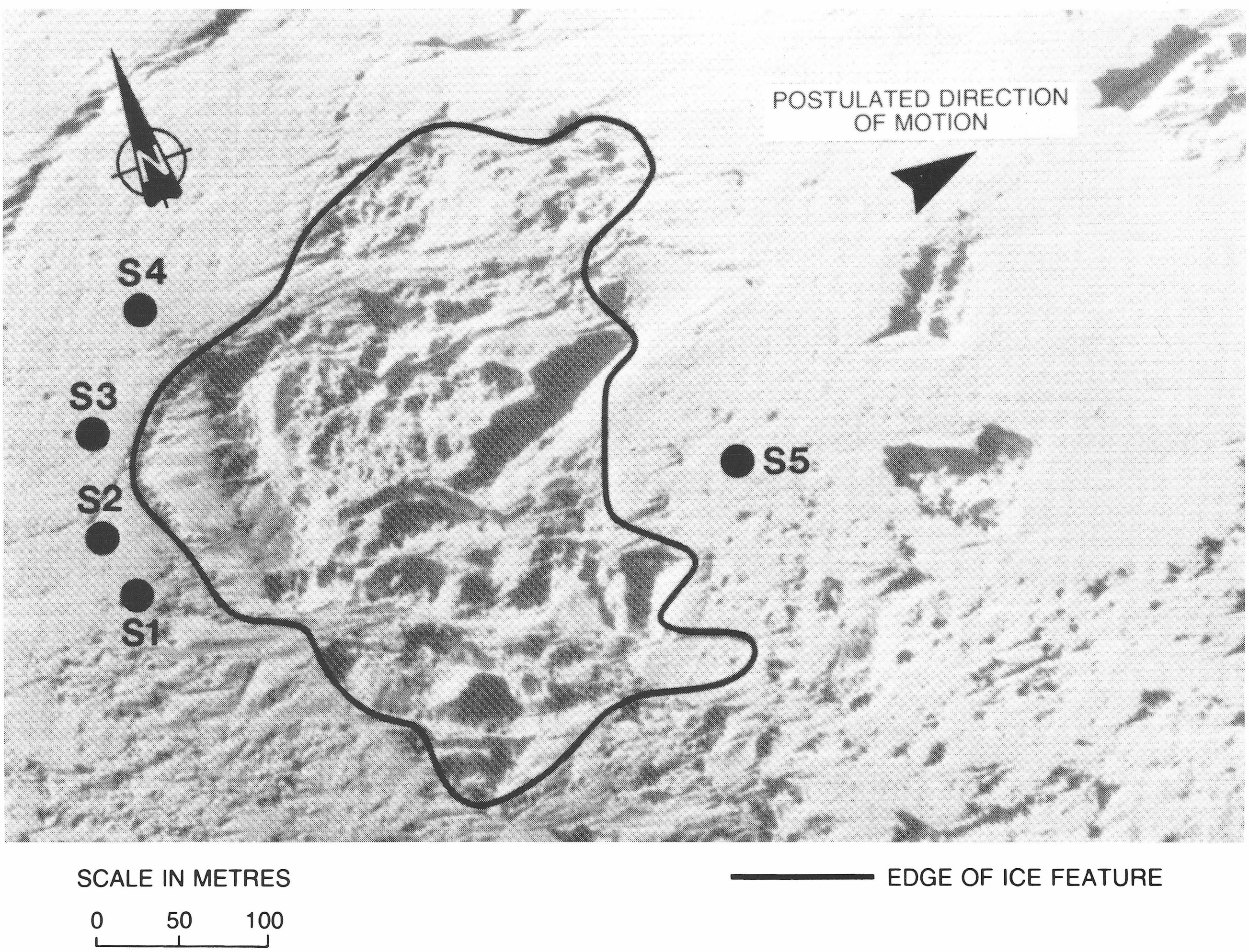


FIGURE 2
PLAN VIEW OF ICE FEATURE

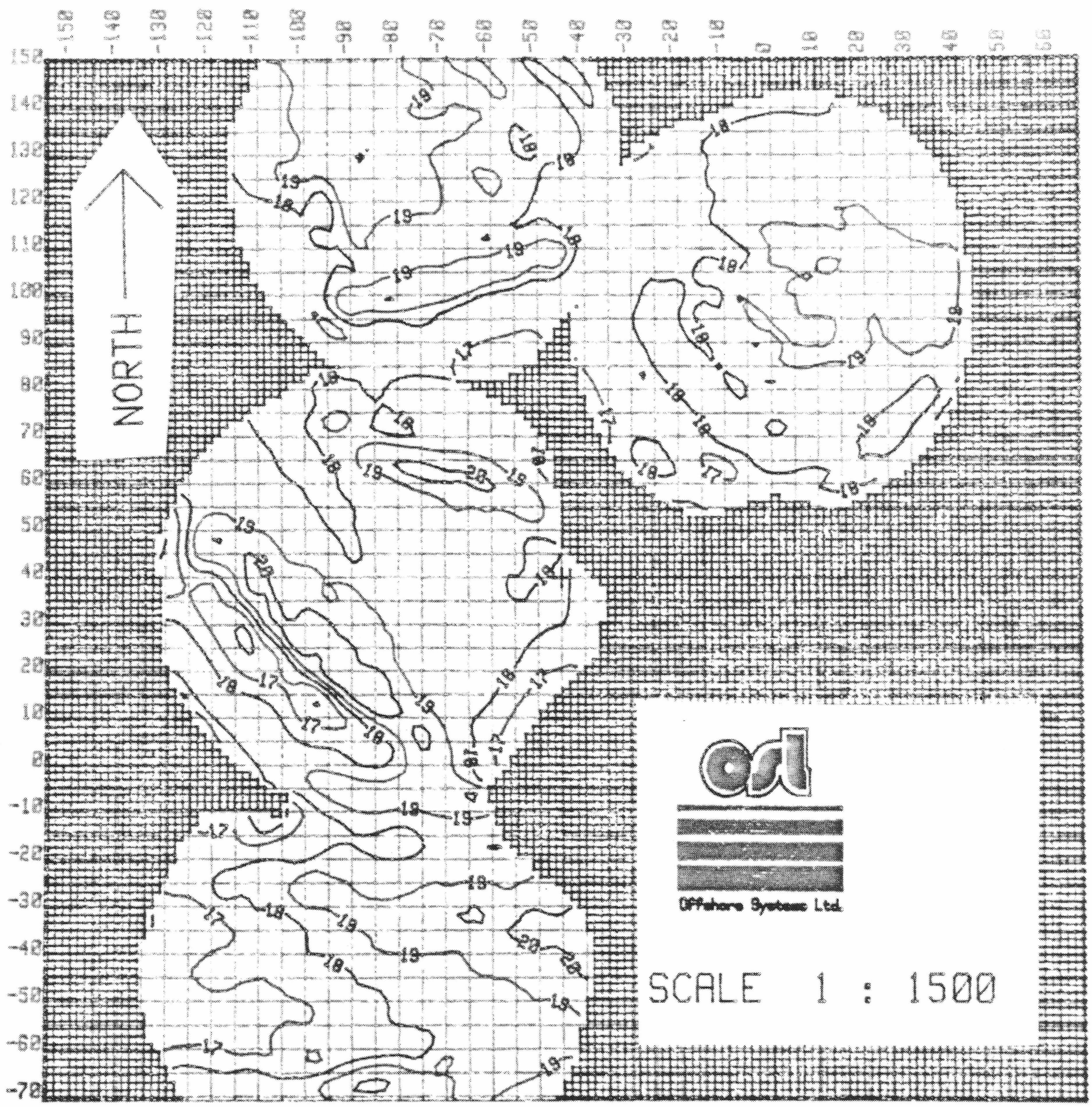


FIGURE 5

MOSAIC OF SEAFLOOR CONTOUR MAPS AROUND ICE FEATURE

A subsequent project involved the measurement of the extent of grounded ice around the Tarsiut N44 island in April 1983. (Ref. 4) The main objective was to determine the geometry and contact area of the grounded ice-rubble annulus around the caisson retained island. This in turn enabled an improved determination of the mechanism of ice load transfer from level ice through the rubble field to the caisson. An estimate of the load transmitted to the berm through the grounded ice was then calculated. Fourteen profiling locations were selected around the perimeter of the berm to provide a representative coverage with their positions being tied in by conventional surveying procedures. Thirty-six radial profiles of the seabed and underside of the ice were obtained with the 952 at each location. In addition to the under-ice profiling, a rotary dual channel 100 kHz side scan sonar was used to provide a 360° rotary side scan record. (Model Klein 521T).

The purpose of this dual measurement approach, which was further complimented by some manual measurements, was to determine accurate slant ranges while at the same time using the analogue side scan data to infill between the profiles. The side scan records enabled the post mission development of mosaics while the digital profile data was generated into contour maps.

The engineering data measured during this project provided the first prototype information on the extent of grounded ice around artificial islands. This in turn contributed to establishing revised design criteria for offshore drilling platforms.

The third under-ice profiling project was performed as a direct result of an unusual intrusion of older ice from offshore Alaska into the Canadian Beaufort Sea in the late summer of 1983. Most of this old thick ice which was composed largely of ridge and hummock field fragments was driven inshore by SE winds and some of it became grounded in 10-25 m water depths. This grounding of large ice features generates indentations in the seafloor known as scours. It is this scouring action which has the potential of damaging subsea oil facilities such as wellheads and offshore pipelines.

Due to the low recurrence frequency of this type of event and the fact that the oil industry is progressing towards full scale production, this event provided an excellent opportunity to assess scour depths. From an engineering perspective, it is important to know the geometry of the scours as they relate to the size of the ice features, their driving force and the seafloor soils.

Local scouting activities were usually necessary to determine acceptable profiling stations as the best location for profiling was often inaccessible. Once a deployment hole through the ice was augered, a colour side scan image of the seabed, 100 m in diameter, could be observed to detect any significant scours and the ice soil interface. Guided by these images the sonar would be redeployed at another augered hole but switched to the profiling mode. Multiple profiles based on a circular plan array with angular horizontal increments of 5° was found to provide sufficient data at the outer perimeter of the scans to construct a realistic contour map of the area within the beam's range.

Figure 2 illustrates a plan view of one site. **Figure 3** illustrates the uplift caused on the ice feature by the seafloor ice keel interaction, while **Figure 4** is the profile measured ahead of the ice feature and indicates a 3 m high spoil pile adjacent to the right hand forward toe of the ice feature. At the rear of the ice feature, several overlapping surveys were performed which indicate a 2 m indentation in the seafloor caused by the scouring of the ice keel. **Figure 5** illustrates the contour plots generated around the ice feature.

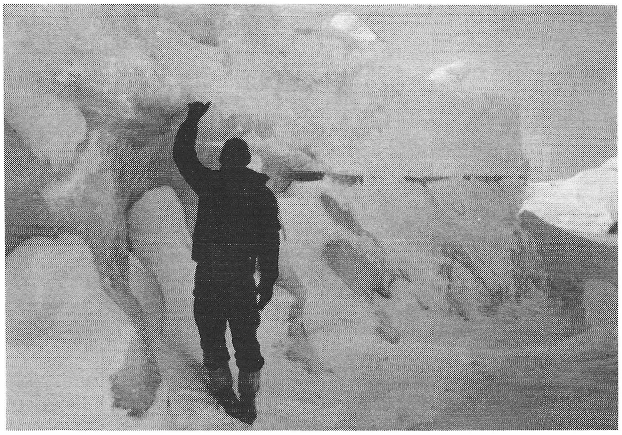


FIGURE 3
EVIDENCE OF 2 METRE UPLIFT ON ICE FEATURE

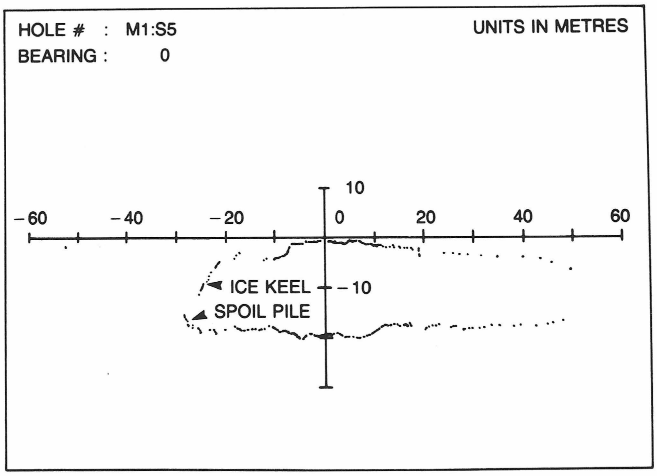


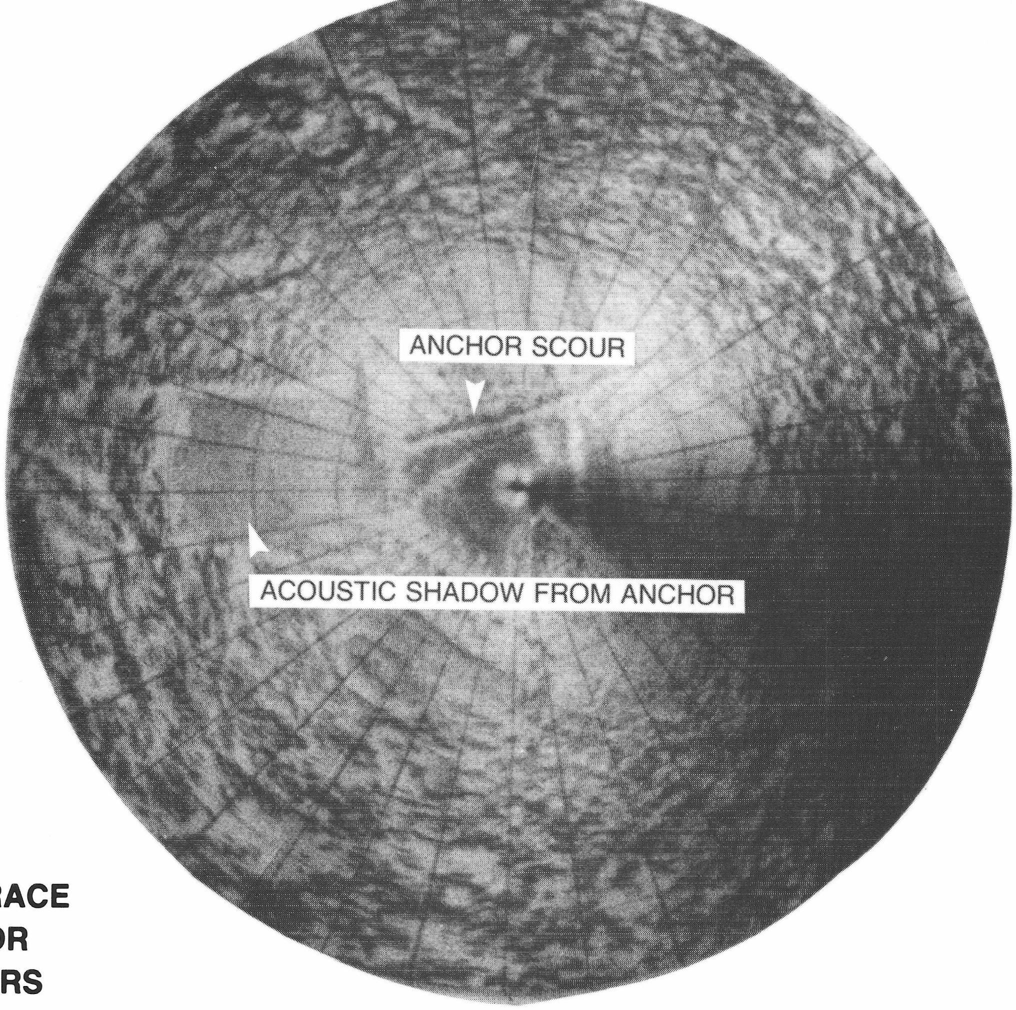
FIGURE 4
PROFILE OF ICE KEEL AND SPOIL PILE

Although budget constraints limited its extent, this project provided some extremely useful information on actual ice scouring mechanisms. It is the understanding of the mechanism which will enable analytical models to be developed to determine appropriate burial depth of pipelines and similar facilities. The flexibility of the dual mode Mesotech 971 sonar which enables rapid identification followed by precise measurement of the relevant data is most advantageous in these types of projects.

Support of Drilling Activities

The same ice incursion which provided such a unique opportunity for measuring ice scour proved most inopportune for the 1983 drilling activities. The **Kulluk**, the new ice class IV conical drilling unit operated by Gulf, was hindered in its drilling activities by this extreme ice occurrence. At both the Pitsiulak A05 and Amauligak J44 wellsites, the **Kulluk** was either pushed off location or forced to evaluate the site rapidly which resulted in anchors being left at Pitsiulak and later the BOP at Amauligak. Recovery and inspection activities were therefore initiated.

An anchor recovery operation using the arctic Class II multipurpose construction barge, the **A. Kiggiak** (Ref. 5) was organized late in October to attempt to locate and retrieve the anchors left at



ROTARY SIDE SCAN SONAR RECORDS (Dark area is not part of record, occurred during photo reproduction)

FIGURE 6

SIDE SCAN SONAR TRACE INDICATING ANCHOR AND ANCHOR SCOURS

FIGURE 7

AUTHOR WITH A RECOVERED 15 TON BRUCE ANCHOR

Pitsiulak. OSPS were once again commissioned to provide the search capability and expertise. **Figure 6** illustrates the results obtained from a Klein model 521T side scan sonar. The Klein model was used, in preference to the Mesotech 971, as it generates a hard copy record which can then be analyzed to identify sonar targets. **Figure 7** illustrates the author with the recovered 15 ton Bruce anchor. Ice conditions during the entire operation were continually deteriorating which caused severe problems in both the search and anchor recovery operations.

Inspection and maintenance of the BOP at the Amauligak J44 site was performed from the anchored Class IV support vessel, the **Miscaroo** with a Hysub 2-20 R.O.V. supplied by Hydrospace Marine Services. The Mesotech 971 was used to locate the blowout preventor (BOP) relative to the anchored, 'Syledis positioned' icebreaker, in conjunction with the Honeywell RS 902, an ultra short base line acoustic positioning system. **Figure 8** illustrates the ROV being deployed with the Mesotech 971 scanning sonar attached above the articulated arms and bumper bar while **Figure 9** illustrates the image of the BOP on the video with the unit switched to the scanning mode. During the search operation, the importance of orientating the sonar beam downwards and ahead of the vehicle became rapidly evident. With the sonar pointing forward and the ROV above the BOP, the BOP would drop from view before the ROV had reached it. As the BOP was in a steep sided gloryhole, (Ref. 5), the ROV had initially to be flown at a slant angle towards the BOP to maintain the BOP in view until its mounting was modified. This operation demonstrated the versatility of the scanning sonar for local search and relative positioning activities.

IMAGING SONAR

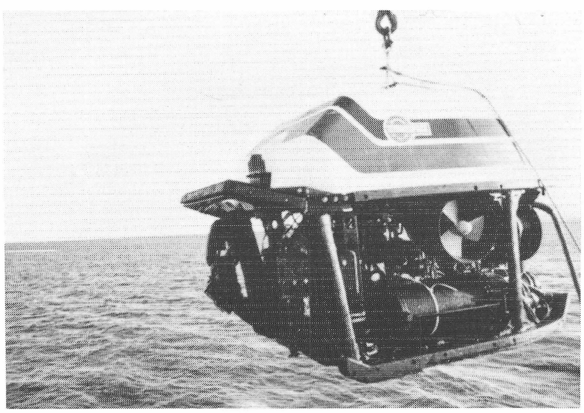


FIGURE 8
DEPLOYMENT OF ROV DURING BOP INSPECTION AT AMAULIGAK J44

is during 'drilling rig' relocations. Drilling in northern latitudes requires the wellhead and BOP to be located below the zone of ice scour. Unlike normal offshore operations, depressions in the seafloor known as gloryholes are excavated in advance to protect the subsea facilities from ice keel interaction. When the **Kulluk** moves to a new drill location, these gloryholes must be identified. Both the Mesotech 952 and 971 have been employed for this operation. **Figure 10** illustrates the Mesotech 952 as it is being deployed through the **Kulluk** moonpool, with the BOP in the background. Where re-entry into a partially completed well is planned, the Mesotech 971 in imaging mode is extremely useful, as a clear return from each of the template guide posts is displayed on the video. Deployment of the sonar must take account of the transducer fan width and orientation. As with the ROV operation, if the orientation is incorrect with the sonar above the target, the target will not be observed.

HONEYWELL ACOUSTIC POSITIONING SYSTEM

SCANNING SONAR WITH BOP ON LEFT OF SCREEN

TWIN REMOTE VIDEO CONTROLS WITH

FIGURE 9
BOP DISPLAYED ON VIDEO WITH SONAR IN IMAGING MODE

Canadian Engineering Surveys Ltd., who have provided Gulf with the majority of their Syledis support, have also utilized the sonar systems for Gulf. (Ref. 6) The drilling structure, the **Molikpaq** which recently delineated the extensive Amauligak field in the Beaufort has been supported by the Mesotech 971 sonar. During 1984, the **Molikpaq** was positioned on the Tarsiut P45 subsea sand berm which acts as the steel caisson's foundation. (Ref. 7) During the set down (mating) operations, several metres inconsistency between the Syledis radio navigation and the Sonardyne acoustic positioning systems required resolution, as set down of the bottom founded structure had to be within ± 2 m. A resection of the **Molikpaq's** position was obtained with range and bearing measurements to the already known position of the acoustic transponders using the Mesotech 971. The acoustic network was demonstrated to be correct and the rig was ballasted down accordingly, within 1 m of the desired location. This novel use of the Mesotech 971 as a relative positioning system saved the day during a very critical offshore operation. **Figure 11** provides an overview of the mating operation while **Figures 12** and **13** illustrate the sonar head deployment and the display consoles on the bridge respectively.

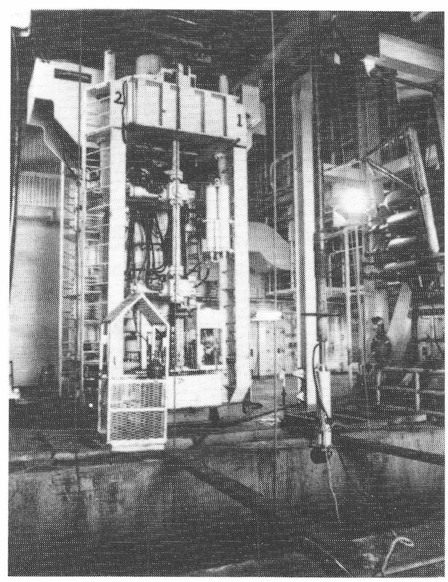


FIGURE 10
952 BEING DEPLOYED THROUGH MOONPOOL DURING KULLUK RIG MOVE BOP IN BACKGROUND

To provide sufficient horizontal resistance against ice loads, the central core of the **Molikpaq** is filled with approximately 120,000 m3 of sand. Sand is pumped into the core from trailer suction hopper dredges which dredge and transport the sand from appropriate borrow areas in quantities of approximately 5,000 m3 per load. Monitoring of the core filling rate is desirable. In 1985, undetermined problems with the profiler prevented any useful results being obtained. In 1986, after some trials in Vancouver, the Mesotech 971 was successfully employed by OSPS to monitor the core removal at Amauligak I65. Four surveys were performed verifying the volume removed and to confirm that no high spots existed. Simultaneously, surveys were conducted on the core discharge build up on the external toe of the **Molikpaq** and on the erosional effect of prop washing by the Class IV icebreaker, the **Terry Fox.**

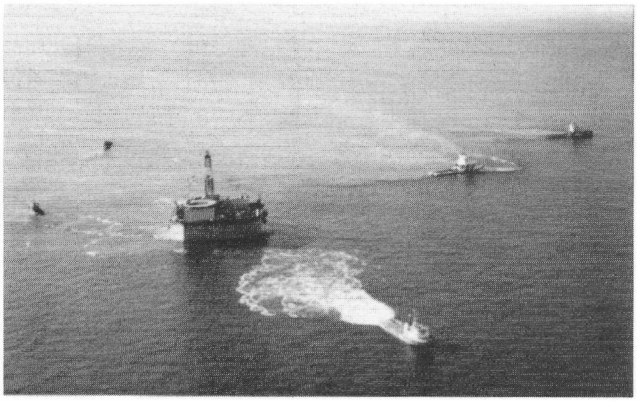


FIGURE 11

MOLIKPAQ BEING POSITIONED OVER THE TARSIUT P45 BERM

To ensure that the **Molikpaq** subsea berm remained intact, berm surveys were scheduled to determine the extent of any erosion by either ice or currents. Both Dobrocky Seatech Ltd. and OSPS conducted over-the-side profiling surveys using the **Molikpaq's** cranes and an aluminum boom arrangement respectively. (**Fig. 14**) The profiling system was able to observe the full width of the berm crest and the sand surface adjacent to the caisson toe, although overlap was kept to a bare minimum. Procedures to minimize the profiling error were implemented, but it was difficult to accurately filter out all the tilt. Furthermore, the considerable wave and current action around the structure could only be partially compensated for during data collection and post processing. In the final analysis, it was determined that accuracy of the contours was only good to 0.5 m. The data collection system is shown in **Figure 15.**

Comparison of the final bathymetric construction survey with the subsequent two sets of **Molikpaq** survey data appear to indicate that some scouring had occurred and this was attributed to ice rather than wave induced current erosion. The measurements were useful in determining gross changes; however, an improved data set remains essential for any conclusive results.

Sonar Utilization in Offshore Construction Projects

Bathymetric profiling of a gloryhole during construction appears an ideal activity for profiling sonar. Gulf, however, has generally excavated gloryholes in such a manner that accurate echosounding surveys are performed during construction from the workbarge itself (Ref. 8). Where trailer dredgers have been used exclusively, as at Amauligak J44 in early 1983, a survey vessel performed a conventional bathymetric survey of the excavation.

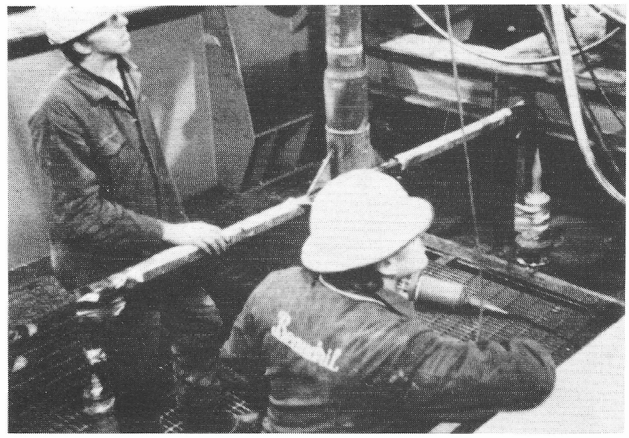


FIGURE 12

DEPLOYMENT OF SONAR 971 AND SONARDYNE ACOUSTIC POSITIONING TRANSDUCER ON MOLIKPAQ DRILLPIPE

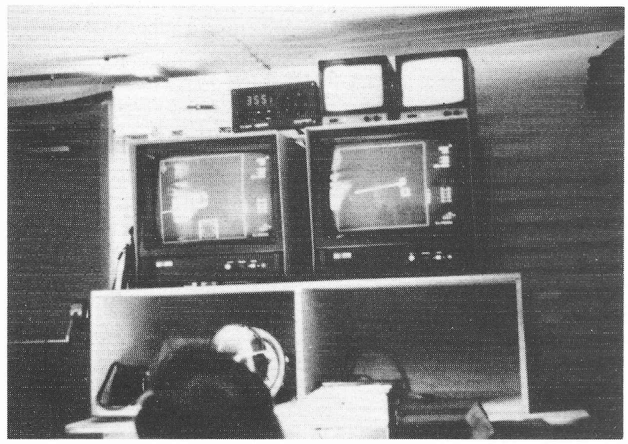


FIGURE 13

LARGE AND SMALL SCALE VDU DISPLAY DURING CAISSON/BERM MATING OPERATION

The only exception was at Akpak P35 in 42 m water depths where the **Geopotes X** had excavated an almost vertically sided gloryhole. Excavation slope is important for stability considerations and as the footprint of the echosounding beam picked up the top of the slope, inconsistencies between surveyed depths and measured dredge drag-arm depth became apparent. The Mesotech 952 with an extended cable was then attached to the drag-arm and lowered to -40m. Good profiles were determined with this method, although the centre of each profile moved slightly as the dredge drifted on its anchors, requiring a hand contoured solution. This project demonstrated the sonar's capability to accurately measure steep slopes while simultaneously illustrating the importance of having a fixed stable, position referenced, platform.

A new approach for excavating cased or uncased gloryholes was developed for the **Kulluk** during 1986. This involved a large diameter (7.3 m) drill bit with a casing follower. (Ref. 9) A joint venture between Cansite Surveys and McElhanney Surveys Ltd. provided the survey support. Real time monitoring of the bit deployment was possible with the Mesotech 971 deployed through the offset divers moonpool. Rather than operate the system in the imaging mode, it was more useful to direct the profiling beam down the marine riser, past the bit to the seafloor. This provided progress information as well as real-time 'slope stability' monitoring. **Figure 16** illustrates the bit and the casing in the main moonpool while **Figure 17** illustrates a cross section of a honeycombed gloryhole (4 holes in a cloverleaf with the fifth hole drifted in the centre). Video records of the installation operation are too blurred to reproduce, primarily because the pixel density on normal video recorders is inadequate for clear duplication of records similar to the high resolution of the 971-3 monitor. For operators requiring a hard copy record, either a high resolution video recorder or a second monitor to enable 35 mm records to be photographed must be arranged.

This project demonstrated the advantage of observing profiled data in real time. From these prototype operations, it appears that the potential for using sonar for real time monitoring of subsea activities in the oil, military and fishing industry is substantial.

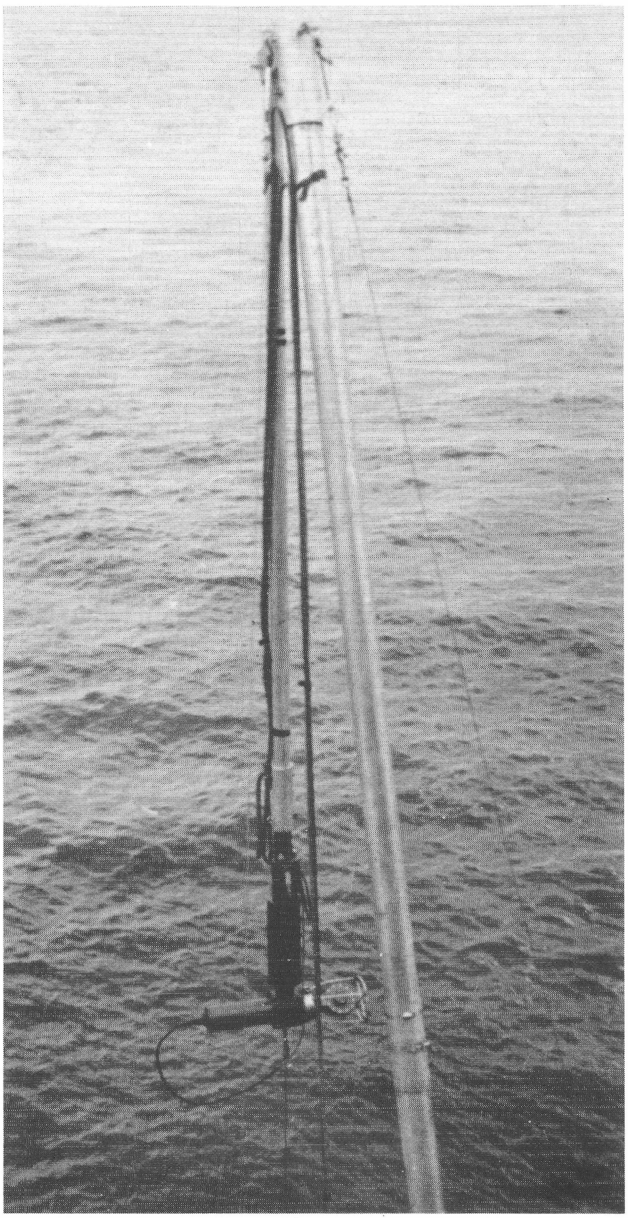


FIGURE 14

SONAR ON SUPPORT FRAME FOR MOLIKPAQ TOE AND BERM SURVEY

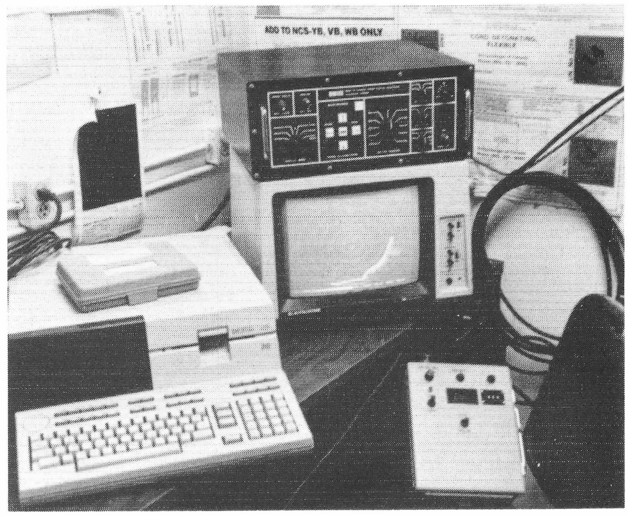


FIGURE 15

SONAR SURFACE SUPPORT SYSTEM

Project Reviews

The types of operations performed by Gulf to date using rotary side scan sonars and profilers has been quite varied. The duration of these projects has significantly been reduced with usually a substantial increase in data collected, as compared with projects employing more conventional techniques. The sonar has also enabled projects to be conducted which were not previously feasible. Experience gained from these operations highlights the advantages of the system while at the same time illustrating some of its limitations. Suffice to say, the author believes that the following items are essential to increase the system's versatiity:

— a fixed working platform for all but ROV search type activities.
— dual axis drive for most operations.
— the capability to switch from image to profiling mode while the unit is deployed.
— a built in inclinometer (a compass option is already available but has only once been used by Gulf).
— an improved awareness of the appropriate transducers for the selected work.
— an inbuilt system for hard copy production.

The manufacturer, together with the survey service companies, are aware that fulfilment of this shopping list will increase deployment cost and hence blunt their competitiveness. Improved rapport between the client and service industry will partially address this, by ensuring that the mobilized system has the characteristics necessary for the project in hand.

In conclusion, it is hoped that this review of experience with scanning sonars and profilers will generate an interest in other related fields such as general hydrographic work and in the fishing industry. It is also hoped that this comprehensive experience with sonar technology gained during support of the offshore oil industry exploration activities will provide a basis for this wider usage.

Acknowledgements

Many of these projects were performed by dedicated sureyors in adverse environmental and budget circumstances. My thanks to all of them for their perseverance and dedication. Thanks are also due to Gulf Canada Corporation for permitting this paper to be published.

References

1. 'Principles of Underwater Sound'. Vrick McGraw Hill, 1975.

2. 'Acoustic Profiling Techniques'. R.G. Lyall, H.H. Lanziner, Proceedings of CPA/CHA Colloquium IV April 1986, pp. 447-494.

3. 'Hydrographic Probe Developed to obtain marine survey data from the ice' by O.M. Kautinen, L.A. Duggan and H.H. Lanziner. American Society of Mechanical Engineers First Conference on offshore mechanics and arctic engineering Volume 2, pp. 229-236.

4. 'Ice/Berm Interaction study using rotary side scan sonar and acoustic profiling systems' by R.R. Good, K.G. Anderson and H.H. Lanziner. OTC 4721, 1984.

5. 'Gloryhole Techniques: Present Techniques and Future Concepts. H.R. Stewart, H.M. Goldby, OTC 4802 1984.

6. 'An Introduction to Offshore Survey Operations in the Canadian Beaufort'. A. Parker, H.R. Stewart, The Hydrographic Journal, No. 31, January 1984, pp. 5-11.

7. 'Molikpaq Deployment at Tarsiut P-45, M.

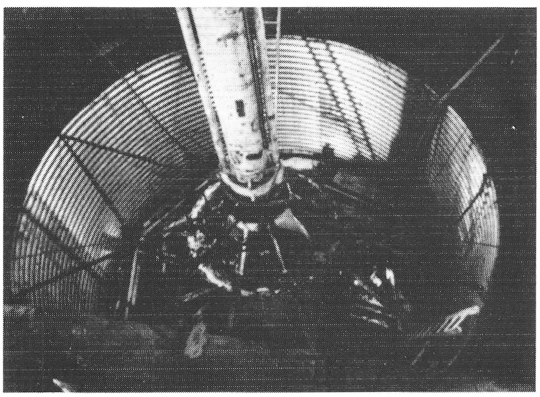


FIGURE 16
24 FOOT GLORYHOLE BIT WITH CAISSON
IN KULLUK MOONPOOL

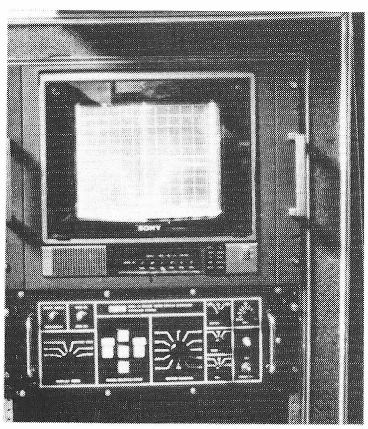


FIGURE 17
MESOTECH 971 DISPLAY OF
A HONEYCOMBED GLORYHOLE

CHA/CHS News

Atlantic Branch

New Executive

The annual General Meeting was held on 27 February 1987 at the Bedford Institute of Oceanography. The Atlantic Branch Executive for 1987 is as follows:

Vice-President	Steve Grant
Secretary	Elizabeth Crux
Treasurer	Charlie O'Reilly
Executive	Ed Lischenski
	Mike Lamplugh
	Kirk MacDonald

During the meeting, the Atlantic Branch Lighthouse Award was presented to Julian Goodyear for his article "Vice-Admiral William Fitz William Owen and his life in Canada" which appeared in the April 1986 edition. The winner of the Crest Contest was Malcolm Jay. Our newest crest will start appearing on Atlantic Branch correspondence shortly. It is virtually identical to the crest that was used for the 1st Biennial Hydrographic Conference held in Halifax in 1985.

The following additions to Hydrographic families were announced:

Charlie & Corinne O'Reilly	a boy
Mike & Karen Collins	a boy
Grant & Debbie McLeod	a boy

Linda MacDonald retired in January after five years with CHS to pursue a career in Real Estate. Ann Ryan retired in February after three years with the CHS. We wish them both the very best in their future endeavours.

Carol Beals is now back working part-time after a lengthy convalescence.

Congratulations to Gerard Costello who graduated in the Spring of 1986 from U.N.B. with a Surveying Engineering degree. He received scholarships and was on the Dean's list. Sean Duffey took his place in September 1986 and has now nearly finished his first year.

The past year has seen a number of CHA events. The summer season was started off with a dinner and harbour cruise on the 57 Ketch "Polaris". Two attempts at combined harbour cruises and picnics on MacNabb's Island during the summer were rained out.

During the winter, two very enjoyable bowling nights and a technical/social evening at the Maritime Museum of the Atlantic were held.

The staff for the new Newfoundland District Office has recently been announced. Members are:

Julian Goodyear	EN-SUR-03
Charlie Stirling	EG-ESS-08
Richard Palmer	EG-ESS-07
Dale Nicholson	EG-ESS-06
Graham Rankine	EG-ESS-04
Dave Thornhill	EG-ESS-04
Sean Duffey	DA-PRO-04

They will work on CSS MAXWELL completing the Passamaquoddy Bay Survey during the first half of the summer and then, with MAXWELL, will move to the new Northwest Atlantic Fisheries Centre in St. John's in August.

Steve "Tutu" Forbes, Charles "Twinkle Toes" O'Reilly and Graham "Tinker-bell" Lutwick participated in the B.I.O. Variety Show last fall in the ballet **Swamp Lake** by "Les Ballets Trompaderoes de B.I.O." The phone has not stopped ringing from National Ballet companies from around the world with lucrative offers since their première performance. A number of leotard manufacturers have also been requesting their personal endorsement. In the same concert, Elizabeth Crux played the female lead role **Mabel** in the Italian Opera "Il Amorato Perjuroso" by Guillermo Gilberti and Arturo Sullivani.

Other CHA members who participated in the concert were June Senay, Debbie Hepworth, Jacquie Blair, Ed Lishenski, Chris Rozon and Bruce Anderson.

Gary Henderson and Julian Goodyear completed all the requirements for the MOT Command Endorsement qualification in December 1986 after about 9 months of study at the N.S. Nautical Institute, Halifax. They are now qualified to command vessels up to 350 tons, such as the CSS MAXWELL.

Central Branch

New Executive

The CHA executive for 1987 is:

Vice-President	Sam Weller
Secretary-Treasurer	Geof Thompson
Executive Members	Terese Herron
	Mike Bennett
	Boyd Thorson
	Bruce Richards
	Dave Pugh
	George Fenn

Personal News

Our congratulations go out to three of our families on the recent arrival of brand new baby daughters:
Brad and Joanne Tinney
— Melanie arrived on May 2, 1986
Ray and Norma Treciokas

— Tania Vanessa on November 4, 1986
Bob and Wilma Johns
— Vanessa on January 12, 1987

Our Branch has several other new arrivals pending, but they didn't make the publication date!

Recent new Branch members include Randall J. Franchuk, Simon Baksh, Darko I. Poletto and Tony Bonnici. Welcome aboard, and we look forward to seeing you at our meetings. Your first beer is on us!

Joe Lamont and Sandy Bishop are now on the Carto I Course in Ottawa, and several of our in-house members are moving around the offices these days. And come the Field Season, others will be moving around, too...

Julie Browning — one of our "honorary hydrographers" — is setting off with a friend (girl) on May 17 for a year's trip around the South Pacific. She'll be stopping over in Hawaii, Fiji, Australia, New Zealand, ... we envy you Julie! She has promised to write a series of reports on her travels for LIGHTHOUSE so we can share her adventures. Watch for her by-line in the next issue!

Our Branch members in private industry continue to prosper, and we met several at a recent evening function. Richard Hancock, for instance, has his own commercial photography studio and is doing well. He has interesting ideas on the role of photography in field surveys, and has promised us an article for LIGHTHOUSE to develop this theme.

We have two members who are with the Metropolitan Toronto and Region Conservation Authority: Jim Berry, is the supervisor of waterfront development, and Richard Padmore, the foreman of hydrographic and land surveys.

Jim Statham is now the Vice President of Surveying with Marshall Macklin Monaghan Ltd., and Bob Moulton is senior instructor in the hydrographic programme at Humber College. Bob reports that there are now about 20 students in the course, with 8 graduating in May. He also has three students from Bangladesh who are on a United Nations exchange program.

We have also had sad news recently, and our heart-felt condolences go out to Bill and Cathy Wade on the death of Bill's dad, Gerry. The CHA lost a valued member, and the family lost a fine person. And this was so soon after the death of Gerry's wife Jean.

Our deepest sympathies also go out to Ruth Andrew and Virginia Hamilton on the recent loss of a close family member.

Activities

During 1986, Central Branch sponsored three technical seminars in addition to our regular meetings, and all three were well received. We plan to continue our Seminar series during 1987, alternating evening meetings with an invited speaker and luncheon seminars. This way, all our members would have a chance to attend some of our functions. We are making renewed efforts this year to keep in touch with our non-CHS members by having interesting evening meetings and social events, and this has been very well received. We look forward to getting to know all our members better this year.

On February 15, the Central Branch hosted the 16th Annual H20 Bonspiel at the Grimsby Curling Club. With many generous sponsors and a total of 56 curlers taking part, this was a really fun day with prizes for all participants. The trophy winners were:
1st Event: B. Thorson, J. Dixon, M. Stapleton and Y. Stokker
2nd Event: P. Warren, C. Kennedy, L. St. James and B. McGoey.

In addition to 15 local sponsors, the following 21 firms were most generous with gifts for our awards table, and we wish to thank them again for all their support!

Geodimeter
Marshall Macklin Monaghan Ltd.
Norman Wade Ltd.
FIG Congress
Digital Equipment Ltd.
J.M. Ellis Ltd.
Telefix Canada Ltd.
Questner Tangent
Wild Lietz
Surnav Corporation
R.C. Marine Electronics Ltd.
Geotec Ltd.
McElhanney
CHA Prairie Schooner Branch
CHA Central Branch
CHA Film Club
Rapid Blueprint Ltd.
Holiday Inn (Burlington)
Royal Bank (Burlington)
Terra Surveys (British Columbia)
Terra Surveys (Ottawa)

The Central Branch also co-sponsored the recent Hydrographic Conference here in Burlington. The Conference Theme this year was "Completing the Picture — The Search Continues", and with 327 registrants, 20 technical papers and 3 major parties (oops! "social events") memorable times were enjoyed by all.

Many of the papers were of exceptionally good quality, and the exhibitors had arranged interesting displays and demonstrations of their tried-and-proven equipment as well as state-of-the-art technology. The Art of hydrography becomes more of a Science with every passing year, it seems, and these Conferences give our members their only real opportunity to keep up with the technological advances of our trade.

Captain Vancouver Branch

New Executive

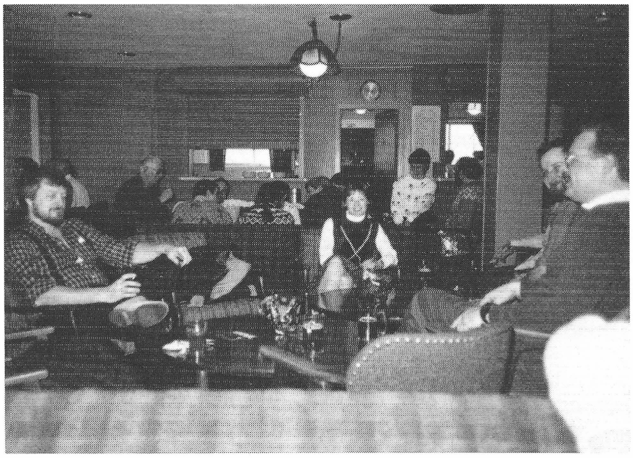
At a General Meeting held on January 14, 1987, the following executive was elected:

Vice-President	Gordon Murray
Secretary-Treasurer	Rick Bryant
Executive Members	R. Lyall
	Tom Roughsedge
	Mike Tarbotton

Our Branch is receiving strong support from the Seattle Chapter of the Hydrographic Society, for the "CANADIAN HYDROGRAPHIC CONFERENCE 1989".

Commander Tom Richards, Chief, Nautical Chart Branch, National Oceanic and Atmospheric Administration, has translated this support into action. He travelled to Vancouver to attend a meeting of the Conference Committee. Tom informed us that the U.S. Hydrographic Conference for the Pacific Coast has been re-scheduled from 1990 to 1992 and this can only be of great benefit to both the U.S. and Canadian Conferences.

Mr. William Hayes, Hydrographic Society of America, President, visited both Seattle and Vancouver recently and met C.H.A. members whilst in Vancouver.



"News from Industry"

A new company has been formed in North Vancouver, "International Hard Suits Inc.". The aims of the company are to complete the development of the "Newtsuit" and the manufacture and marketing of the same.

Aris Morfopoulus, who has been Director of Sales at Can-Dive Services Ltd. for the past ten years, is the General Manager of the new company.

Mark Doucette has joined Offshore Systems Ltd. in the capacity of Executive Vice President. Offshore Systems Ltd. provides the marine navigation and offshore industries with electronic charts, specialized navigation equipment and surveying services.

Ottawa Branch

New Executive

The Ottawa Branch Executive for 1987 is as follows:

Vice-President	Dick MacDougall
Secretary-Treasurer	Shiela Acheson
Executive Members	Diana Pantalone
	Kathy Young
	Rene LePage
	Roger Landriault
	Tom Cassidy
Past Vice-President	Terry Tremblay

Activities

The Ottawa Branch held regular executive meetings during 1986 and a general meeting in January, 1987. The branch organized a Christmas luncheon that was attended by more than 70 persons.

Ottawa Branch members made up a large percentage of the 14 CHS, headquarters staff who attended the CHA/CHS Conference in Burlington.

Personal News

- Rollie Gervais left the CHS in February, 1987 after 37 years of service.
- Neil Anderson has been to Indonesia advising the Canadian International Development Agency (CIDA) on establishing a Marine Sector development project.
- Bob Hinchley supported the Through Ice Bathymetry System (TIBS) trials in the Arctic this winter.
- Lung-fa Ku has returned from a two year assignment with IMO in Bangladesh.
- P.K. Mukherjee is participating in a project entitled "Operation of Hydrographic/Research Vessels" sponsored by the International Centre for Ocean Development (ICOD)/IOC of UNESCO. He is writing a chapter on the legal aspects of vessel management and operation for the project manual.
- Mike Wolfe and J. Papineau attended the CHS Cartography II Course held at Ottawa.
- Ilona Hilbert-Mullen attended the CHS Cartography I Course held in Ottawa.

Pacific Branch

New Executive

The new CHA executive for 1987 is:

Vice-President	Mike Woodward
Secretary	John Larkin
Treasurer	Willie Rapatz
Newsletter	Mike Bolton
Membership	Rob Hare
Seminars	John Watt

The executive has been meeting on the second Monday of every month, to prepare for the meetings in Burlington, and to make plans or the coming year. Thoughts of the coming conference in Vancouver in 1989 are in order.

Eight members of Pacific Region attended the Burlington conference, and all were impressed with the event. Thanks are due to CHA in Burington for their hospitality.

Lighthouse edition 34 arrived in early December and was distributed to the members.

Congratulations to Barry Lusk on becoming the National President.

Recent Seminars

Jim Vosburgh of Terra Surveys gave a lunchtime talk on LIDAR surveys in the Arctic, at the IOS auditorium.

Thomas Richards of NOAA gave a talk on the Divisions of NOS. More than 70 members and guests attended this luncheon meeting at Glen Meadows Golf and Country Club. Several members of the Seattle chapter of the Hydrographic Society of America were also present.

Education

Alex Raymond and Bruce Lewis wrote CLS exams in February. No results have been received. Good luck on the outcome. Pete Milner is still at UVIC. Knut Lynberg and Rob Hare have completed Hydrography 2, and have been awarded their certificates. George Eaton passed his professional exams and is now G. Eaton, P. Eng.. Dave Prince and Bent Neilsen are in Ottawa on Cartography I.

Trips Abroad

Knut Lyngberg and Barbara Kerr spent the last several months in the southern hemisphere. Knut bicycled around New Zealand, Barb toured several islands in the South Pacific. Jim Vosburgh recently returned from the Far East, where he was lecturing on LIDAR survey techniques. Mike Bolton spent some time in Mexico and Barry Lusk went to Hawaii. Numerous others have spent time skiing up at Mount Washington, which has once again had a bumper year for snow (rain?, fog?). Ron Woolley is leaving shortly for an extended vacation in Africa. He plans to be away for four months.

Houses

Ken Halcro and Carol Nowak, and Ernie and Cathy Sargent, all have purchased houses in the recent past. The house warming parties all appear to have been successful, and we wish them luck in their new homes. Fred and Andrea Stephenson, and Barry and Gail Lusk, and Kal Czotter also purchased new homes in the last year.

Social Events

The annual CISM co-sponsored BBBB (Beer, Bun and Bellowing Bash) was a great success this year, partly due to the large turn-out. It was held at the Knights of Pythias Hall in Sidney, and not downtown, which may have helped the turn-out somewhat. Several members of NOAA from Seattle attended this year, but we managed to keep the trophy (Best Beer, Bun and Bellowing Basher) in Canada.

New Additions

The IOS baby boom continues:

Ernie and Cathy Sargent
— a boy, Geoffrey David
George and Nancy Eaton
— a girl, Emma Felicie
Les and Nancy Pickell
— a boy, Thomas
Alex and Cathy Raymond
— a girl, Barbara
Fred and Andrea Stephenson
— a girl

Ongoing CHS Pacific Activities

"PENDER", Vern Crowley in charge, is continuing the survey of Clayoquot Sound. Kal Czotter, 2-I-C, hopes to put the Micro VAX 2 to the test as a field survey tool this year.

"L. PACIFICA", Alex Raymond in-charge, is planning a complete resurvey of Vancouver Harbour. Ernie Sargent is 2-I-C, and ISAH will be used, and the range bearing package will no doubt get a thorough workout.

"RICHARDSON", Frank Coldham in-charge, will survey Prideaux Haven, Cumshewa and Rivers Inlets. A DPW barge will be used on the MacKenzie River project, mid-season. George Schlagintweit is 2-I-C.

Other Surveys

Mike Woods is in charge of the shore party and local surveys this year, while George Eaton will be working with Terra Surveys on LIDAR projects, and Barry Lusk is once again monitoring contract surveys.

The JOHN P. TULLY will not be used for hydrographic surveys this year.

Mike Woodward is leaving soon to carry out current surveys in and around Seymour Narrows.

Personal News

Both Bruce Lewis and George Schlagintweit are making marriage plans. Bruce in August and George in October. Good Luck and goodbye bachelorhood.

Ron Woolley and Neil Sutherland are trading jobs this year. While Ron is working for the Tides and Currents Section, Neil will put the skills that he acquired last year in Hydrography I to some use, on the Vancouver Harbour Survey.

John Larkin's daughter is going to tour Russia with Stages West Dance Troupe.

Congratulations to Ken Holman and John Larkin on recent milestones. Twenty-five years with the public service.

Condolences to Ray Chapeskie on the recent death of his father.

Members of the New Zealand Hydrographic Service, visited IOS on February 11th, to look at ISAH and some of our other automated systems.

Terra Surveys

The Larsen 500 airborne scanning laser bathymeter successfully carried out another survey program in the southern route of the N.W. Passage. An advance control party using GPS equipment established the location of the remote Trisponder stations. With this work completed, Jim Vosburgh (Chief of Remote Sensing) and Kirk Stead proceeded to carry out ground truth measurements of earlier Lidar survey work from '85 in the areas of Cambridge Bay and Simpson Strait. Their work was initially hampered by an abnormally bad ice year, however, several ground truth sites were successfully sounded as well as a number of light transmissmeter profiles taken. As ice cleared off the proposed Lidar survey sites, Jim directed the aircraft to Cambridge Bay and within two days was collecting Lidar data in Simpson Strait. Upon completion of this survey, the operation shifted to Requisite Channel where much of the work was completed before adverse flying conditions precluded further work.

The Mackenzie River conventional hydrographic program finished near the end of the summer with the survey launches performing even better than expected. Digital data files of all sounding and positioning information were made in the field and proved to be very useful in the field to select shoal examination and survey detail. After the post survey data processing, editing, and quality control, a total of 10 field sheets have been completed. With the chart production progressing smoothly, Brian Clarke, the Hydrographer in charge of the project is breathing a sigh of relief after a very intensive effort which began for him last spring even before the ice had left the Mackenzie River.

We are pleased to announce that Paul Conrad has joined the staff at Terra Surveys as Systems Analyst. Paul has been a key person in the Lidar program's software development. Paul is based in our Sidney, B.C. office.

Quester Tangent Corporation

Mr. Lorne Fidler, President, Quester Tangent Corporation of Victoria, B.C. announced that he and Mr. Paul Lacroix, Vice President, have concluded an agreement for the purchase of Quester Tangent Corporation from Interact Research and Development Corporation. Messrs. Fidler and Lacroix are joined by Mr. John Watt who will continue as the Vice President, Marketing, a position he has held with the company since September of 1985.

Mr. Lacroix, the principle designer of the ISAH (Integrated System for Automated Hydrography) data acquisition and processing computers states that the company will continue with the sale and support of ISAH technology in the international marketplace. Mr. Watt adds that the company objective is to develop as an integrated marine technology company marketing Canadian products in the international marketplace.

Région du Québec

L'association a tenu son assemblée générale annuelle, le 31 janvier 1987, à Mont-Joli. Les membres présents ont pu visiter les installations du S.H.C. situées à l'Institut Maurice Lamontagne et assister à une conférence de monsieur Yvon Dufour traitant du pilotage sur le St-Laurent.

À cette même assemblée, un nouvel exécutif a été élu. L'exécutif 1987 de la section du Québec se compose de:

Vice-président	Denis Hains
Secrétaire-trésorier	Normand Doucet
Conseiller	Marc Journault
Conseiller	Yvon Boulanger
Conseiller	Yvon Dufour
Conseiller spécial	Richard Sanfaçon

Deux membres du conseil n'oeuvrent pas au sein du S.H.C. ce sont messieurs Yvon Boulanger, arpenteur-géométre et professeur à l'Institut de marine, ainsi que Yvon Dufour, pilote et gradué en astrophysique de l'Université Laval.

La première réunion de l'exécutif s'est tenu le 23 fèvrier demier à l'Institut de marine de Rimouski.

Denis Hains et Richard Sanfaçon ont représenté l'exécutif règional lors de la réunion annuelle de l'A.C.H., qui avait lieu à Burlington, les 16 et 18 fèvrier.

Une trentaine des soixante-dix membres de l'association ont déjà payé leur cotisation annuelle. Les objectifs d'accroissement pour l'année en cours devraient porter ce nombre à 150.

Dans le cadre du Programme de Développement de l'Emploi, l'un des neufs projets soumis par l'association a été accepté. Le projet a débuté le 9 mars dernier et a permis l'embauche d'une agente de communication, Louise Brassard. Celle-ci s'occupera principalement de la gestion et de la correspondance de l'association, section du Québec, mais ègalement de la prèparation d'un colloque prévu pour la fin de la prèsente année. Une autre personne entrera en fonction au début du mois de mai.

Nous profitons de l'occasion pour remercier la direction de l'Institut de marine qui a gracieusement preté un local pour le déroulement des activités de ce project.

Le S.H.C. région du Québec a emménagé de façon définitive à l'Institut Maurice Lamontagne de Ste-Flavie, le 11 novembre 1986.

Le S.H.C. région du Québec a participé dernièrement au salon nautique de Montréal, tenu du 27 fèvrier au 8 mars.

On annoncait récemment la fusion de la compagnie rimouskoise J.L. Electron avec Quester Tangent Corporation de Victoria. Ceux-ci se spécialisent dans l'instrumentation hydrographique et océanographique.

Nous vous rappelons que l'adresse postale de l'A.C.H. section du Québec est:

180 de la Cathédrale
C.P. 1447
Rimouski
Québec
G5L 8M3

Obituary
Gerald Elmer (Gerry) Wade

Gerald Elmer Wade, known as Gerry or Gunner to his friends, was a most valued member of the Canadian Hydrographic Association and passed away on December 1, 1986 after a long battle with leukemia.

Gerry was born in Fredericton in 1922 where he received his primary and secondary education. Gerry volunteered to serve his country at the age of 17 and spent over five years in the services, serving with the Canadian forces in the Mediterranean and Western Europe during the war. This is where he picked up the nickname "Gunner", by which many of his friends knew him.

After the war, Gerry attended Mount Allison University and earned his Engineering certificate in 1949. Gerry obtained his B.Sc. from Carleton University, a DLS, and also two Provincial survey licences (Nova Scotia and Prince Edward Island).

Gerry's surveying life started with the Department of Mines and Resources, Topographic Survey Branch. However, in the spring of 1951, he transferred to the Canadian Hydrographic Service. He rose from a junior hydrographer's position to a hydrographer-in-charge of surveys in a short time. Gerry worked on the major survey vessels BAFFIN and ACADIA on the east coast. As well as working on southern surveys, he spent many years in the Arctic. These surveys included combined Canadian-Danish and Canadian-American surveys as well as a host of other scientific projects.

After he retired from the Canadian Hydrographic Service in 1977, Gerry established the Hydrographic Surveying programs at Humber College and Erindale College (University of Toronto), himself teaching courses in this program.

In his report to the Canadian Hydrographic Association Annual General Meeting in February 1987, J.H. Weller, Vice-President of Central Branch, included the following comments on Gerry's contribution to the Canadian Hydrographic Association:

> "... Gerry was one of the original dozen hydrographers who first conceived the idea of this Association in 1966, and all through these years he has supported our organization with his efforts and his enthusiam even when he was most ill. He was our National President the year we made an official affiliation with the Canadian Institute of Surveying, and with his long and warm relations with C.I.S., he represented us well there, both officially and behind-the-scenes ..."

A thorough, companionable, consistent and humble person, Gerry and his wife Jean had a wonderful relationship. His son Bill and Bill's wife Cathy shared his complete trust and affection. He will be greatly missed by his sisters Barbara and Marion, brother Gardiner, and the other members of the family.

His fellow workers held him in high regard for his professionalism and integrity. We will all miss him. He was a fine man.

Raj Beri

News from Industry

Ulvertech America Inc.

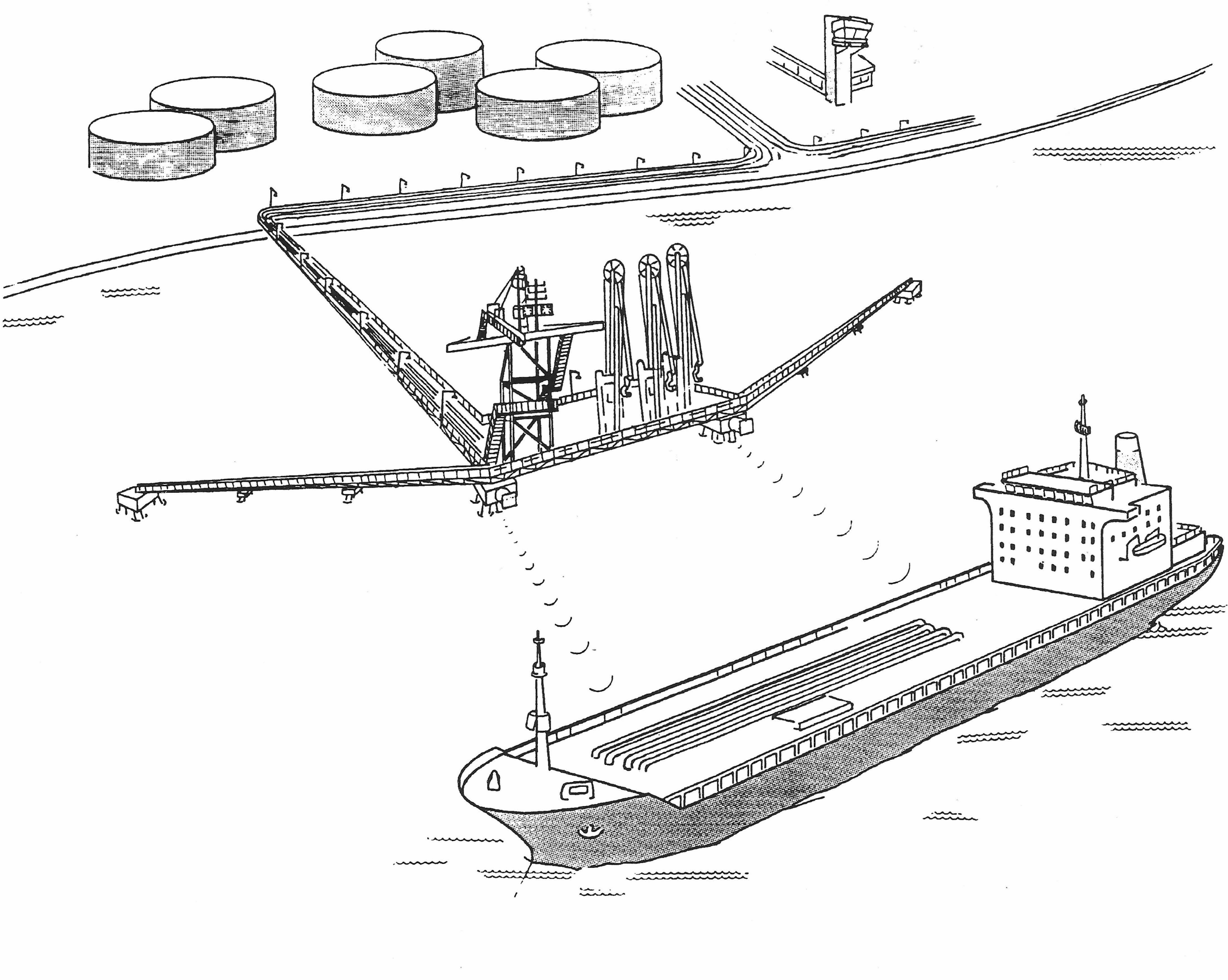
Ulvertech announce a new 500 kHz Dual Scanning Profiler system as an optional feature for their standard 1 megahertz model which has been used, with some considerable success, in various undersea precision measurement projects. The two-degree conical beam echo sounder is mechanically rotated through operator selectable arcs from 0° to 180°. By using two "heads" the profiler eliminates acoustic shadow effects and provides ranges up to 80 metres.

The system provides a capability for fast real-time records of dredge-sites, bottom contour scouring, sediment transport, inspection of underwater structures, particularly for pipeline or cable trenching/plowing operations.

Navitronics AS

Whilst berthing, the final few metres to the quay are critical if damage to the ship and the quay is to be avoided. The NAVITRONIC vessel berthing system has been developed for use in this operation. It consists of two transducers mounted on the outer face of the quay and is based on the company's dual channel echo-sounder, the soundig-30. The system measures the distance between the transducers and the berthing vessel and this information is presented in a graphic form with scale 0-20m, 0-50m, 0-100m and 0-200m with automatic switch-over.

The distance information is fed into a computer which then calculates the speed and the approach angle. The data are compared with built-in values and the information is displayed prominently on the quay.



Hydrographic Services International Ltd.

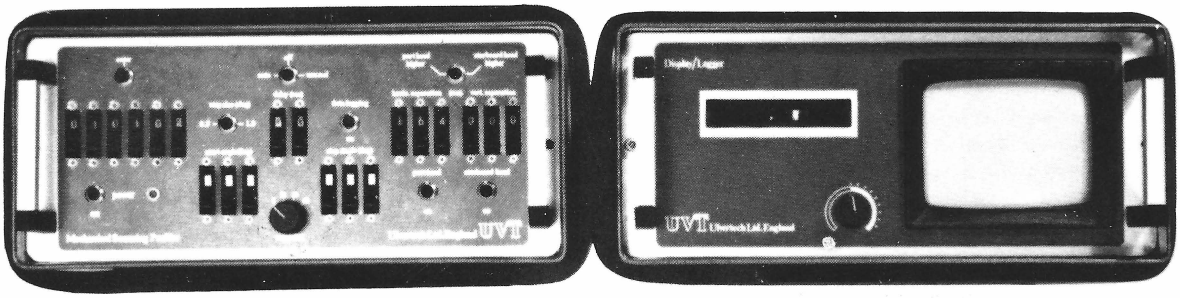
In response to demand from industry, Hydrographic Services International have developed an intelligent data logger able to acquire and store data at the rate necessary for modern high resolution bathymetric surveys and which is operable on 12 or 24 volts DC, as provided on most small launches.

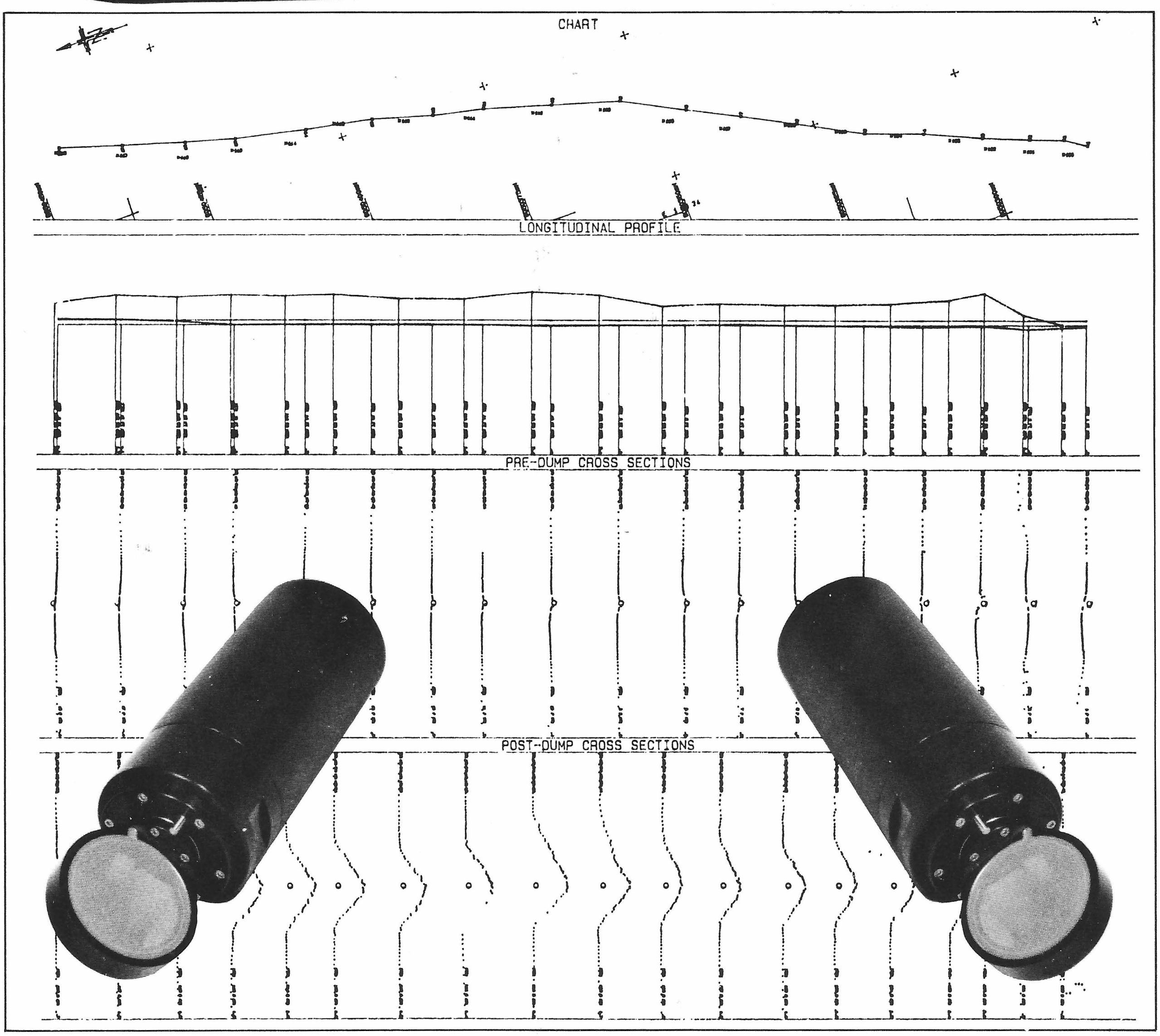
The new unit achieves storage speeds far in excess of conventional loggers by means of a custom designed operating system which is able to utilise the popular Hydrolink high-speed interface modules. These interface modules enable users to greatly extend the capabilities of small desk top computers by dedicating their own on-board intelligence and storage capacity to the task of peripheral communications management, thereby leaving the computer free for real time navigation, etc.

Under control of the data logger's operating system, these modules are able to acquire sounder and positioning data at peripheral service rates of up to twenty cycles per second and then log this information, together with time and operator references (line + fix number, etc.), onto a rugged three and a half inch flexible disc.

The logger may be interfaced with a range of positioning systems, and echo sounders via standard Hydrolink interface cards. This enables the surveyor to compute, display and record the ship's track using a variety of navigation equipment either onboard the vessel (e.g., microwave ranging or range and bearing systems), or via a telemetry link (e.g., a manual or tracking laser ranger), and to integrate this positional data with depth soundings using the time reference from the logger's real time clock.

DUAL SCANNING PROFILER



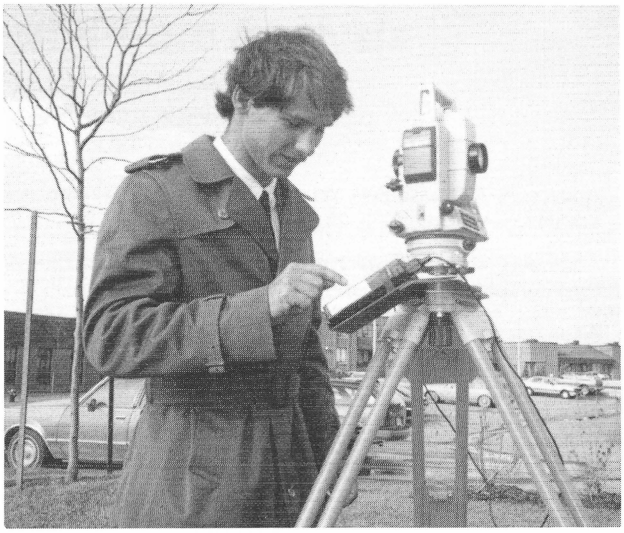


Logging parameters and operator references (line + fix number, etc.) may be entered using either the data logger's full 'qwerty' keyboard and 8 line display, (which also shows status messages, data and position), or loaded directly from a configuration disc.

Data discs can be transferred from the loggers to HSI's bathymetric post-processing system for editing, volumetric calculations and chart production.

Telefix Canada

Telefix Canada has created a new division, the Customer Service Group, which will provide short-term assistance on customer survey projects. Survey companies can now hire operators, equipment or both on a daily basis. More information and rates can be obtained by calling 889-9534 in Toronto or 1-800-263-3581 outside Toronto.



Index of Articles

LIGHTHOUSE Editions #01 through #35
Listing is in alphabetical order of author(s) followed by title,
year of publication, edition and page number.

Eaton, R.M. **How is Satnav coming along these days?** 1975, 12, 7.

Eaton, R.M. **Loran-C at extended range for fishing and oceanography in Atlantic Canada.** 1976, 14, 3.

Eaton, R.M **An accurate log for icebreaker type ships.** 1977, 15, 35.

Eaton, R.M. **The Acadia goes to the Nova Scotia Maritime Museum.** 1980, 21, 12.

Eaton, R.M. **Range errors in microwave.** 1981, 23, 26.

Eaton, R.M. **Opinions — smoothing and multi-ranging.** 1982, 25, 39.

Eaton, R.M., Macphee, S.B. **Book reviews.** 1982, 25, 31.

El-Sabh, M.I., Murty, T.S., Briand, J.M. **Storm surge amplitudes in the St. Lawrence estuary.** 1979, 20, 8.

Evangelatos, T.V. **Upgrade of cartographic workstations.** 1985, 32, 5.

Falconer, A.R. **Cesium controlled Decca Lambda system.** 1972, 10, 6.

Fenn, G. **Laser ranger evaluation.** 1977, 16, 34.

Fisheries & Oceans. **Gazetteer of undersea feature names 1983.** 1983, 28, 47.

Fitzgerald-Moore, P. **The metric system.** 1970, 04, 11.

Forbes, S., Burke, R.G., White, K.T. **Digitization — how the Atlantic Region is approaching the problem.** 1977, 15, 14.

Freeland, H.J, Mackas, D.L., Denman, K.L. **An upwelling gyre off the west coast of Vancouver Island.** 1982, 26, 7.

Freeman, N.J. **Guidelines for the Tides, Currents and Water Levels Unit, Central Region.** 1972, 09, 72.

Furuya, H. **The Canadian Hydrographic Service Hydrography I and Hydrography II courses.** 1982, 25, 5.

Furuya, H. **The Canadian Hydrographic Service courses in Marine Cartography.** 1982, 26, 1.

Gamble, S.G. **The metric system.** 1970, 04, 10.

Gauthier, R.E., Saucier, R. **The General Bathymetric Chart of the Oceans, 5th edition.** 1976, 13, 11.

Gervais, J.M. **Summary of 1971 field season with technical operations.** 1972, 10, 38.

Gilbert, R. **CSS Baffin mid-life refit.** 1977, 16, 37.

Goldsteen, G.H. **Report on visit to Dutch hydrographic offices.** 1972, 09, 37.

Goldsteen, G.H., Casey, M.J. **A simple method of making copies of field sheets in the field.** 1972, 10, 55.

Goldsteen, G.H., Casey, M.J. **A simple method of making copies of field sheets in the field.** 1973, CE, 53.

Goodyear, J. **Book review.** 1981, 24, 38.

Goodyear, J.E. **Vice Admiral William Fitzwilliam Owen, and his life in Canada.** 1986, 33, 21.

Gottinger, R. **Computerized chart reproduction for scientific applications.** 1979, 20, 4.

Gourley, M.J., Turpin, J. **Loran-C callibration of large scale charts.** 1983, 28, 23.

Gray, D.H. **Verifying the Gulf of Maine computations.** 1985, 32, 13.

Gray, D.H. **Implementation of North American datum of 1983 into CHS National charting program.** 1986, 33, 16.

Gray, D.H., Monteith, W.J. **Integration of NAD 83 into the charting program of the United States and Canada.** 1981, 23, 6.

Gray, N.S. **Reminiscences of a retired hydrographer.** 1983, 28, 41.

Hall, F.W. **Book review — electronic surveying and navigation.** 1978, 17, 30.

Hally, P. **Un survol historique de l'hydrographie au Canada français.** 1982, 26, 10.

Hammack, J.C. **Landsat goes to sea.** 1978, 17, 3.

Harris, S. **Strictly personal.** 1972, 09, 46.

Hemphill, M.A., White, K.T. **Evaluation of Motorola's Mini Ranger data processor and automated positioning system.** 1978, 18, 15.

Henderson, G.W. **The hydrographic survey of Fury and Hecla Strait.** 1982, 25, 32.

Huggett, W.S. **Technique for mooring underwater instruments on the continental shelf.** 1971, 08, 18.

IFYGL staff. **Marine Sciences Branch contribution to International Field Year for the Great Lakes.** 1972, 09, 1.

Jacobs, A.F. **The metric system — notes for a position paper.** 1970, 04, 12.

Jerome, J.H., Bruton, J.E., Harris, G.P. **The application of Landsat-1 digital data to a study of coastal hydrography.** 1977, 16, 11.

Johnson, B.R. **Statistical analysis of pingo-like features in the Beaufort Sea.** 1970, 2, 6.

Kenny, B. **A cartographer's experience on a field survey.** 1986, 33, 10.

Kerr, A.J. **Canadian sailing directions — some recent and planned changes.** 1972, 10, 23.

Kerr, A.J. **Antarctic survey — twenty years ago.** 1975, 12, 51.

Kerr, A.J. **Sailing strategy in the face of the Gulf Stream and North Atlantic current.** 1977, 16, 7.

Kerr, A.J. **The Amoco Cadiz and all that.** 1978, 18, 21.

Kerr, A.J. **The case of the poached lobsters.** 1980, 21, 9.

Kerr, A.J. **Surveying the sands off Sable.** 1983, 27, 22.

Kerr, A.J. **An opinion, computer assistance.** 1985, 31, 3.

Kerr, A.J. **The influence of international standards on the training and education of hydrographers.** 1985, 32, 29.

Keilland, P. **Using the digital data base to see between the lines.** 1983, 28, 49.

Knox, R.W. **The Mercator projection.** 1970, 04, 17.

Lachapelle, G., Eaton, R.M., Mertiks, S. **Impact of global positioning system on hydrography.** 1984, 29, 41.

Lasnier, L.R. **Exchange programme comments.** 1971, 08, 7.

Lin, S. **Second Institute of Oceanography, China.** 1983, 27, 34.

Linton, R.H.W. **International Cartographic Association — Marine Cartography Commission.** 1984, 30, 11.

Loncarevic, B.D. **Modern hydrography as seen by a geoscientist.** 1976, 13, 6.

Lung-fa, K. **The largest tides in the world.** 1984, 29, 30.

Lusk, B.M. **Canadian Hydrographic Service Centennial.** 1984, 29, 14.

Macdonald, E., Macdonald, G.D. **From a hydrographer's sketchbook impressions of India.** 1981, 23, 22.

Macdonald, G.D. **Sounding off.** 1970, 03, 70.

Macdonald, G.D. **Items of interest.** 1971, 06, 70.

Macdonald, G.D. **Cook and Canada.** 1975, 12, 35.

Macdonald, G.D. **The origin of 'The Origin of the Species'.** 1979, 20, 10.

Macdonald, G.D. **The man who had been right.** 1980, 21, 14.

Macdonald, G.D., Boyce, F., Macdonald, E. **Stories of Canada's lakes and rivers.** 1983, 27, 13.

Macdonald, G.D., Bryant, R., Marshall, R. **Coastal survey in Africa using Loran-C.** 1977, 15, 3.

Macdonald, G.D., Casey, M.J. **Integrated navigation system.** 1976, 14, 34.

Macdougall, J.R. **Tellurometer MRD1 field evaluation.** 1980, 21, 5.

Mackenthun, D. **Accuracy Survey Positioning Control.** 1987, 35, 12.

Macnab, R., Smith, T.B. **CSS Baffin survey — Beaufort Sea 1970.** 1971, 06, 70.

Macphee, S.B. **An evaluation of the Sea Beam system.** 1977, 16, 3.

Macphee, S.B. **How often should charts be reissued.** 1984, 30, 18.

Malone, A.K. **Dolphin — on trial.** 1983, 28, 9.

Malone, A.K. **Book review.** 1984, 29, 22.

Marshall, H. **Cartoon.** 1973, 11, 38.

Marshall, R. **International Great Lakes Levels Board.** 1971, 06, 70.

Maunsell, C.D. **Who measures depth?** 1971, 08, 14.

Maunsell, C.D. **Who measures depth?** 1973, CE, 37.

Maunsell, C.D. **The speed of sound in water.** 1976, 13, 20.

McCulloch, T.D.W. **The hydrographic commission of FIG.** 1980, 21, 1.

McCulloch, T.D.W. **Canada's hydrographic role in FIG.** 1978, 17, 1.

Mckinnon, N.J. **The value of experience.** 1970. 03. 70.

Mclintock, G., Macdonald, G.D. **Bubble memory.** 1983, 28, 4.

Medendorp, J., Macdonald, G.D. **The marine Arctic route reconnaissance system.** 1981, 24, 13.

Meyer, E.A. **"Smart" digitizer proven in Arctic.** 1981, 24, 32.

Millett, P. **Experiences with a smart digitizer.** 1982, 26, 19.

Milner, P.R. **The Microfix 100c.** 1983, 28, 26.

Mitson, R.B. **Fisheries sonar.** 1984, 29, 22.

Mogg, M.I. **The 1980 H.M.S. Breadalbane expedition.** 1980, 22, 23.

Monahan, D. **Geometrical probability and hydrography.** 1978, 17, 10.

Monahan, D. **Municipal place names and hydrographers.** 1979, 19, 12.

Monahan, D. **Satellite bathymetry — fact or fiction?** 1984, 29, 24.

Monahan, D. Casey, M.J. **Contours and contouring in hydrography part II — interpolation.** 1984, 30, 30.

Monahan, D.T.A., Wooglavin, S.J. **Cartographic design considerations for the electron chart.** 1986, 33, 10.

Mooney, B.J. **The impact of Fundy tidal power on the hydrography of the area.** 1978, 18, 9.

Mortimer, A.R. **A note on the calibration of Decca 6F with minifix.** 1971, 08, 1.

Mortimer, A.R. **Comments on the Internav Loran-C co-ordinate converter unit (cc-2).** 1979, 20, 22,

Muir, L.R. **Quick Loran-C to geographic conversion.** 1982, 25, 26.

Murphy, D.S. and Tarbotton, M.R. **An Application of Acoustic Core Analysis.** 1987, 35, 12.

Murty, T.S. **Sunspot activity and tsunamis in the pacific ocean.** 1983, 27, 31.

Murty, T.S. **Meteorology and oceanography in the Falkland Islands region.** 1982, 26, 7.

O'Connor, A.D. **The Yuasa 12 volt battery.** 1971, 08, 35.

O'Connor, A.D. **Pavlov's hydrographers.** 1981, 24, 2.

O'Connor, A.D. **Annual report.** 1984, 29, 22.

Palmer, R. **Recovering datum reference.** 1983, 28, 39.

Perrin, J. **Big increase in fatalities on the water.** 1973, 11, 46.

Prinsenberg, S.J. **Sound velocity distribution and its effect on sounded depths for Hudson Bay.** 1978, 17, 24.

Richards, P. **Water crossing — Strait of Mackinac.** 1972, 10, 1.

Richardson, G.E. **Evaluation of the Klein Associates side scan sonar.** 1971, 07, 1.

Richardson, G.E. **Assignment Egypt.** 1982, 25, 3.

Ritchie, G.S. **The chart and the metre.** 1970, 04, 8.

Ritchie, G.S. **Review — The future of Hydrography.** 1984, 29, 21.

Ritchie, G.S., T.A., Lamb, W.K. **The voyage of George Vancouver 1791-1795.** 1985, 32, 3.

Rockwell, G. **Large scale surveys with the Aga geodimeter 120.** 1981, 23, 18.

Rogers, A.R. **Discussion corner.** 1970, 03, 70.

Rogers, A.R. **Talk presented to Pembroke Outdoor Sportsman's Club.** 1971, 08, 17.

Rogers, A.R. **Seminars.** 1973, 11, 78.

Ruffman, A. **Some comments on Canadian Fishermens charts 43058 A 85 of the Sable Island Bank.** 1985, 32, 20.

Sallaway, P. **A review of digital terrain modelling applied to hydrographic charting activities.** 1981, 24, 23.

Sandilands, R.W. **Is this a record?** 1970, 03, 70.

Sandilands, R.W. **The history of hydrographic surveying in British Columbia.** 1971, 07, 29.

Sandilands, R.W. **E.S.P. quiz.** 1972, 09, 71.

Sandilands, R.W. **The history of the Hydrographic Service in British Columbia.** 1973, CE, 1.

Sandilands, R.W. **Thoughts of a field hydrographer.** 1973, 11, 45.

Sandilands, R.W. **CSS Pandora II.** 1975, 12, 40.

Sandilands, R.W. **The survival of hydrography.** 1976, 13, 18.

Sandilands, R.W. **There is a proper measure in all things. (horace).** 1976, 14, 15.

Sandilands, R.W. **The Cook Bicentennial.** 1977, 15, 13.

Sandilands, R.W. **I am become a name (Tennyson).** 1977, 15, 33.

Sandilands, R.W. **There is no new thing under the sun.** 1977, 16, 36.

Sandilands, R.W. **Sydney's hydrographer.** 1978, 18, 13.

Sandilands, R.W. **Feds solve 4 year old crime.** 1978, 18, 20.

Sandilands, R.W. **Whose name was writ in water.** 1979, 19, 1.

Sandilands, R.W. **Charlie Golf Foxtrot Quebec.** 1979, 20, 1.

Sandilands, R.W. **The Canadian Princess.** 1980, 22, 30.

Sandilands, R.W. **Charting the Beaufort Sea.** 1981, 24, 10.

Sandilands, R.W. **Reminiscences of the Admiralty Newfoundland survey.** 1982, 26, 42.

Sandilands, R.W. **J.P. Tully.** 1984, 30, 14.

Sanfacon, R.S. **Canadian Hydrographic Workshop, Quebec, 1982.** 1981, 24, 4.

Shreenan, J.G. **Construction of velocity scales for MS 26B echo sounders on conversion to the metric system.** 1971, 06, 70.

Silvey, W. **A tale of Mac.** 1971, 08, 13.

Smith, A. **GEBCO.** 1970, 03, 70.

Smith, A. **Chart user survey.** 1976, 13, 13.

Stephenson, F. **An assessment of the permanent water level stations in the Canadian arctic.** 1977, 16, 21.

Stewart, H.R **Five Years of Scanning Sonar Experience in the Beaufort.** 1987, 35, 12.

Stoughton, H.W. **Water level transfers to determine geodetic elevations.** 1982, 25, 26.

Stuifbergen, N. **Maxiran trials on the Scotian Shelf.** 1977, 16, 26.

Stuifbergen, N. **Syledis — a new medium-range positioning system.** 1978, 18, 6.

Stuifbergen, N. **Minifix winter trials in Northumberland Strait.** 1983, 27, 35.

Tarbotton, M.R. and Murphy, D.S. **An Application of Acoustic Core Analysis.** 1987, 35, 12.

Thompson, E.F. **Navigational ranges survey.** 1971, 07, 17.

Thompson, E.F. **CHA co-sponsored bonspiel.** 1973, 11, 75.

Thomson, D.B. **Hydrographic surveying in the context of the Surveying Engineering Program at the University of New Brunswick.** 1977, 16, 28.

Thomson, D.B., Okenwa, E.G. **Analytical models for automated water level reduction of soundings.** 1980, 21, 16.

Tinney, B. **Automated tidal reductions.** 1977, 15, 19.

Tripe, R.L.K. **NAVBOX — a microprocessor-based navigation aid.** 1978, 17, 14.

Vachon, D.H. **Next generation plotters.** 1985, 31, 24.

Vanicek, P., T.A. Carrera, G. **The use of sea level tide gauge observations in geodesy.** 1985, 31, 13.

Varma, H.P. **Canadian data report on hydrography and ocean sciences no.** 1984, 29, 33.

Varma, H.P. **Interactive graphics editor for hydrography.** 1984, 30, 20.

Varma, H.P. **Evaluation of the QUBIT TRAC IV B.** 1985, 31, 5.

Varma, H.P., Henderson, G.W. **The advantages of using a ship as a dynamic MRS station.** 1984, 30, 28.

Wade, G.E. **Seminar presentation at Canada Centre for Inland Waters.** 1972, 09, 66.

Wade, G.E. **Interest in the arctic.** 1973, CE, 40.

Warren, J.S. **New bathymetry for the Queen Elizabeth Islands.** 1983, 28, 35.

Watt, J.V. **Towards a maximization of information recorded on hydrographic echograms.** 1977, 15, 25.

Watt, J.V. **Dependable digital depths.** 1978, 18, 24.

Weedon, G.F.C., Gilb, T.P. **"Range Holes" and what to do about them.** 1976, 13, 2.

Weller, J. **The reluctant hydrographer.** 1971, 06, 70.

Weller, J. **The happening at James Bay.** 1973, 11, 66.

Weller, J.H. **Our revisory summary.** 1971, 08, 38.

Weller, J.H. **Monumenting and description of survey stations.** 1972, 10, 46.

Weller, J.H. **Cartoons.** 1972, 09, 36.

Weller, J.H., Kerr, A.J., Eaton, R.M. **Book reviews.** 1982, 26, 25.

Wells, D.E. **Datum transformations.** 1976, 13, 8.

Wells, D.E. **Mathematics and computing syllabuses for hydrographers in Canada.** 1981, 24, 34.

White, G.J.A. **Some thoughts on the metric system.** 1970, 04, 6.

White, K.T. **CHA Atlantic branch minutes of meeting April 24, 1970.** 1970, 04, 25.

Woods, M.V. **The mini-ranger data processor automated positioning system — a useful tool for positioning sweeps.** 1979, 19, 7.

Woods, M.V. **Horizontal accuracy of soundings and the ARGO DM-54.** 1986, 33, 5.

Wright, B.M. **Lower St. Lawrence survey, 1971.** 1971, 06, 70.

Wright, B.M. **Minamata and Mercury.** 1971, 06, 70.

Wright, B.M. **Minamata and Mercury.** 1972, 09, 34.

Wright, B.M. **HYDRODIST in Central Region.** 1972, 09, 64.

Wright, B.M. **Minamata and Mercury.** 1973, CE, 16.

Wright, B.M. **HYDRODIST in Central Region.** 1973, CE, 34.

Wright, B.M. **Report on MINI-FIX operations in James Bay.** 1973, 11, 1.

Wright, B.M. **While memory serves.** 1984, 29, 8.

Index of General Topics

Listing by year of publication:

News from industry. 1983, 28, 60.

CHA/CHS news. 1983, 28, 56.

Social activities from years gone by (50's and 60's). 1984, 30, 44.

New hydrographic survey catalogue. 1984, 30, 27.

1984 Canadian Hydrographers Association Workshop. 1984, 29, 16.

CHA/CHS social news. 1984, 29, 50.

The Canadian Hydrographic Service and Canadian Hydrographers Association. 1984, 30, 48.

Message from the president. 1984, 29, 3.

Obituary. 1984, 29, 48.

International Cartographic Association Marine Cartography. 1984, 29, 7.

Editorial. 1984, 30, 9.

News from industry. 1984, 30, 46.

Editorial. 1984, 29, 3.

Retirements. 1984, 29, 48.

Lighthouse awards. 1984, 29, 7.

CHA/CHS social news. 1984, 30, 45.

CHA/CHS workshop on hydrographic data processing. 1984, 30, 27.

Second International Hydrographic Technical Conference. 1984, 30, 27.

Message from the president. 1984, 30, 19.

News from industry. 1984, 29, 52.

News from industry. 1985, 32, 32.

President's message. 1986, 33, 13.

Pictorial display — lighthouses. 1986, 33, 14.

Canadian Hydrographic Association list of members. 1986, 33, 33.

CHA/CHS News. 1986, 33, 27.

News from industry. 1986, 33, 29.

New constitution for the Canadian Hydrographic Association. 1986, 33, 31.

Editor's Notes. 1986, 34, 5

President's message. 1986, 34, 6.

CHA/CHS News. 1986, 34, 43.

Profiles of Candidates for President. 1986, 34, 47.

News from industry. 1987, 34, 50.

Editor's Notes. 1987, 35, 12

President's message. 1987, 35, 12.

CHA/CHS News. 1987, 35, 43.

Obituary. 1987, 35, 33.

News from industry. 1987, 35, 50.

Index of Articles. 1987, 35, 50.

Determine your precise position
PULSTRAC™ System Configured for GPS Integration

Pulstrac

The first precise positioning system to be passive, self-calibrating and self-initializing. This navigation system is accurate to within 2 meters dynamically.

Trisponder Systems

Precision microwave, line-of-sight radio location and guidance equipment composed of up to 8 transponders and a digital distance measuring unit. They offer flexible modes of operation: range/range, range/bearing and XY position.

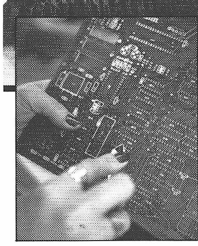
UHF Trisponder Systems

Over-the-horizon system that utilizes the latest in solid state technology. The UHF system utilizes spread spectrum techniques for maximum range and optimum signal to noise ratio.

Worldwide Service

Del Norte now offers a **TWO-YEAR** warranty. Representation and factory authorized service are available worldwide. For more information on the full Del Norte product line, write or call.

Del Norte Trisponder® and Pulstrac™ positioning and navigation systems provide unsurpassed accuracy and reliability.

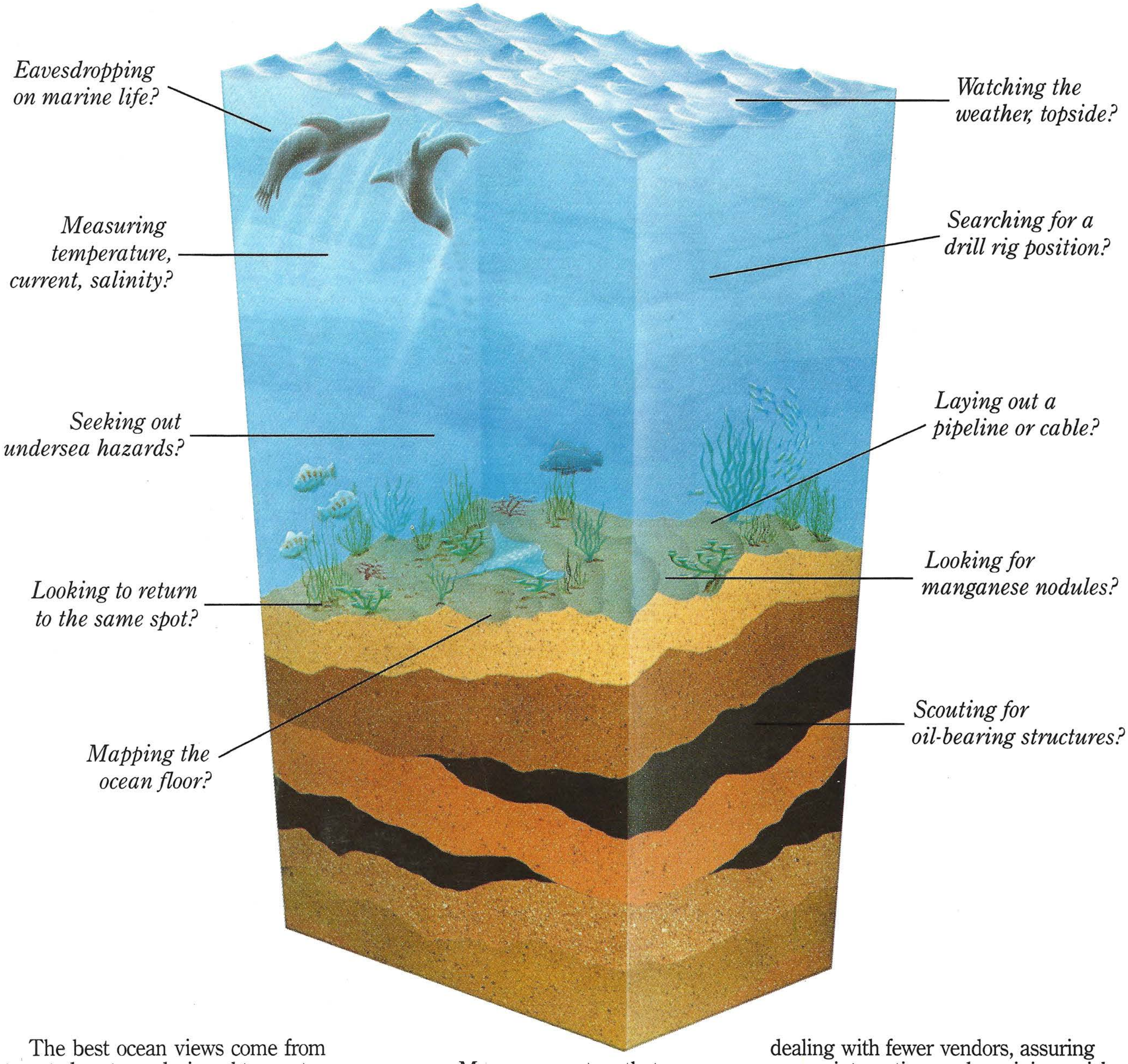


DEL NORTE Technology, Inc.

1100 Pamela Drive, P.O. Box 696
Euless, Texas USA 76039
Texas: 817 267-3541   US: 1-800 433-7505
Telex: 26 2449 DEL NORTE EULESS
FAX: 817 354-5762


FALCON technology
puts you in profitable positions.
Cost-cutting accuracy from the MINI-RANGER® Falcon™ Family. The Falcon IV for turnkey automatic positioning, the 484 and 492 with calculator interfaces for range only or range plus X-Y position. With real-time range quality control. For geophysical and hydrographic positioning or tracking multiple mobile targets. Call 416/499-1441 about profitable Falcon system positioning or write to Motorola Position Determining Products, 492 McNicoll Avenue, Willowdale, Ontario, Canada M2H 2E1.
MOTOROLA INC.
Government Electronics Group

HOW DO YOU SEE THE SEA?



The best ocean views come from integrated systems designed to meet your specific mission needs. Which is exactly what Magnavox delivers.

Based on 20 years of Magnavox experience, these highly accurate integrated systems include navigation, data control, data logging and data processing. You select exactly what you want in your system with your choice of leading edge subsystems such as Differential GPS, familiar navaids including Transit, Loran-C and others, plus integration to a full range of sensors for seismic, oceanographic or hydrographic surveys. Modular design means a Magnavox system that can handle any mission need—and expand to grow into your future requirements.

Since your system comes from a single, reliable source, you benefit by dealing with fewer vendors, assuring proper integration, and receiving quick delivery of a working system at an affordable price. And as a further advantage, your system is backed the world over by Magnavox product support.

Improve your view of the ocean today. Contact Magnavox Navigation and Communications Systems Marketing, 2829 Maricopa St., Torrance, CA 90503 U.S.A. Tel. (213) 618-1200, Ext. 3050. Telex 696101. Cable MAGNAMAR

Magnavox
Magnavox Advanced Products and Systems Company

6125/7/86